ISSN 0377–9335

ENTOMON

Vol. 25 June 2000 No. 2

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Kariavattom, Trivandrum, India 695581

ENTOMON

ENTOMON is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other arthropods.

Address MS and all editorial correspondence to Managing Editor, ENTOMON, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695581, India.

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ENTOMON 25(2): 73–80 (2000)
Article No. ent.25201

Electrophoretic Protein-pattern of Male and Female Haemolymph and Ovary of *Oxya hyla hyla* (Orthoptera : Acrididae) and Preliminary Identification of Female-specific Protein-Vitellin

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ABSTRACT: Male and female haemolymphs and egg extract of *Oxya hyla hyla* were subjected to different electrophoretic analyses with a view to identify the vitellogenic protein. Native PAGE analysis of buffer soluble male and female haemolymph proteins revealed eleven bands with no difference in R_m values. But native PAGE as well as SDS-PAGE analysis of detergent extract revealed sharp differences. The native PAGE revealed difference of one band (R_m value 0.17) and SDS-PAGE analysis revealed difference of three bands. The molecular weight of those female-specific (egg-specific) peptides were 69.2 kD, 64.6 kD and 59.6 kD respectively.

KEYWORDS: Protein-patterns, Native PAGE, SDS-PAGE, Haemolymph, Vitellin, *Oxya hyla hyla*, Electrophoresis, Orthoptera.

INTRODUCTION

It is well established that insect blood or haemolymph is a store house of various kinds of proteins and enzymes (Wigglesworth, 1972). By using electrophoretic and antigen-antibody precipitation methods a good number of proteins have been demonstrated in insect haemolymph and it has also been made sufficiently clear that the number and quantity of different fractions vary depending on the stage of insect development as well as its ecophysiological conditions (Wyatt and Pan, 1978). The major haemolymph proteins which have been characterized so far include storage proteins, lipoproteins, ovarian proteins, antibacterial proteins, lectins, protease inhibitors, different enzymes, chromoproteins, metal binding proteins and hormone carrier proteins (Kanost *et al.*, 1990). Apart from these still there are many other proteins which await characterization. Among these proteins, the female-specific ovarian protein, vitellogenins have received much attention. This is the precursor protein of egg yolk (Pan *et al.*, 1969). It is deposited in the yolk as vitellin

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(Wyatt, 1980) and is synthesized under the influence of juvenile hormone (Chen and Wyatt, 1981) in the fat body and then released in the female haemolymph during vitellogenesis and subsequently taken up by the oocyte (Nordin *et al.*, 1990). Although it has been reported in the haemolymph of male insect (Lamy, 1984), it is not commonly found in male insect, and hence it is generally considered as a female specific protein (Houseman and Morrison, 1986; Shinoda *et al.*, 1996).

Among orthopterans locust vitellogenin has been characterized (Chinzei *et al.*, 1981). Only little information is available on vitellogenin of any Indian insect in general and orthopteran in particular. Therefore, as a part of the programme for characterization and purification of vitellin in the Indian grasshopper *Oxya hyla hyla*, the present communication reports electrophoretic analysis of male and female haemolymphs and egg protein targeted towards identification of vitellin.

MATERIALS AND METHODS

Insects

For this study fresh insects *(Oxya hyla hyla)* were collected from the paddy fields around Agartala. The reproductive males and females were separated, provided with *Eichhornia* vegetation *ad libitum* and sacrificed as and when necessary.

Collection of haemolymph and egg

The hind limbs of fresh male and female insects were cut and the thoracic regions were pressed. The oozing out haemolymph were collected by pre-PTU-rinsed unmeasured capillary tubes.

After taking the haemolymph, the females, were sacrificed and the developed oocytes were collected and weighed.

Preparation of protein solution

Male and female haemolymph (50 μl each) were collected separately in the micro-centrifuge tubes containing 50 μl chilled extraction solution (50 mM Tris-Cl, pH 7.2 with or without 0.1 M NaCl) (Harnish and White, 1982) and placed in the container filled with ice. Each of the solution was mixed well in the vortex and centrifuged in cold condition (5000 g for 30 minutes). The supernatants were taken out in other microtubes and kept at 4 °C till use. For acetone precipitation 50% acetone concentration was made. Solubilization was done in buffer solution containing 2% Triton X-100, (Andrews, 1981) as the sample was insoluble in buffer only.

Matured oocytes were homogenized (10%) in a glass homogenizer (using the same chilled extraction solution) placing that in the cold container. Then as usual mixing was done in the vortex and centrifuged in the same manner. The upper yellow layer of fatty substances were separated out from the supernatant by glass wool filtration. The clear supernatant was electrophoresed directly or subjected to acetone precipitation (final acetone concentration 50%). It was then thoroughly mixed and centrifuged (5000 g for 30 minutes). The precipitate was separated and dried in reduced pressure to get

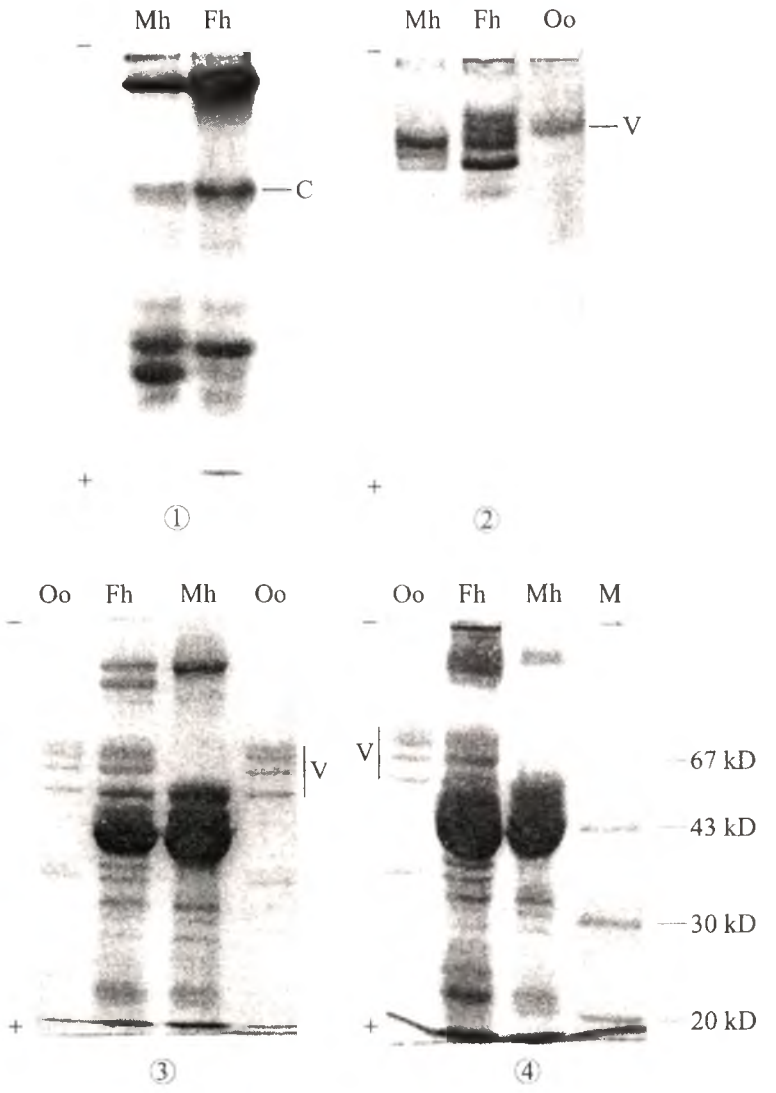

FIGURE 1. Photomicrograph representing the buffer soluble protein band after native PAGE analysis (Mh = male haemolymph, Fh = female haemolymph). C represents the pigment carrying protein.

FIGURE 2. Photomicrograph of electrophorogram of acetone powder of male haemolymph (Mh), female haemolymph (Fh) and egg protein (Oo) solubilized in Tritron X-100. The egg-specific protein V (vitellin) is absent in male haemolymph.

FIGURE 3. Photomicrograph of SDS-PAGE analysis showing the contrasting picture of male haemolymph (Mh), female haemolymph (Fh) and egg proteins (Oo).

FIGURE 4. Photomicrograph of comparison of SDS-PAGE analysis of male haemolymph (Mh), female haemolymph (Fh) and egg proteins (Oo) against the molecular weight markers (M). Egg-specific proteins are marked as V.

the powder form of the protein. The powder was then dissolved in solubilizing buffer (50 mM Tris-Cl, pH-8.3 containing 2% Triton X-100) (Andrews, 1981).

Electrophoresis

Male and female haemolymph samples along with egg protein solution were separately analyzed in native (Davis, 1964) as well as in SDS-polyacrylamide gel electrophoresis, (Laemmli, 1970) using 6% and 8% gel respectively. The electrophoretic system for this analysis was run at room temperature using constant current of 3–4 mA per lane. As usual leaching of the gels were done in the fixer and then stained with Coomassie brilliant blue R-200. The molecular weights of the proteins were determined by comparing those with molecular weight markers (Pharmacia).

RESULTS

1. Native PAGE analysis of male and female haemolymph proteins and ovary extract

After centrifugation, buffer extract of male and female haemolymphs had been subjected to native PAGE analysis. It revealed eleven protein bands in both the haemolymph (Fig. 1, Table 1). In case of the female haemolymph the protein band with the R_m value of 0.07 was very thick and perhaps it was a composite band but no definite conclusion could be drawn from this. The band with R_m value 0.31 was perhaps a chromoprotein as that band appeared green in the unstained gel by naked eye and band with R_m value 1.0 was a carotene bearing protein as that appeared yellow in unstained gel. This band has also reported by other workers (Law, 1990). Similar analysis of the egg proteins failed to reveal any observable protein band. That indicated that egg proteins were not soluble enough in low strength buffer or failed to penetrate the gel.

2. Native PAGE analysis of acetone-powder of male and female haemolymph and egg proteins

Acetone powder dissolved in buffer solution containing 2% Triton X-100 revealed interesting features. The male haemolymph showed the presence of five observable protein bands, while the female showed six distinct bands. The results have been presented in Fig. 2 and Table 1. On comparison of both the pictures it has been observed that the male haemolymph protein with the R_m value 0.23(E) was absent in the female haemolymph while in the female haemolymph two distinct protein bands B and C (R_m values 0.14 and 0.17 respectively) were absent in the male haemolymph. The acetone-powder of egg extract showed presence of only three bands (C, F, G). The R_m values of such bands were 0.17, 0.26 and 0.32 respectively. All the bands were present in female haemolymph while 'C' was absent in male. The band with R_m value 0.17(C) was the only thick band present in both female haemolymph and egg. Such comparison distinctly showed that the egg protein band with R_m value 0.17(C) was naturally female-specific in nature and homologous with 'C' of female haemolymph.

TABLE 1. Comparison of R_m values of male haemolymph, female haemolymph and egg proteins of *Oxya hyla hyla* under different electrophoretic conditions

Native PAGE of buffer extracts			Native page of acetone extracts in presence of Tritron X-100				SDS-PAGE analysis			
	Male haemolymph	Female haemolymph		Male haemolymph	Female haemolymph	Egg		Male haemolymph	Female haemolymph	Egg
A	0.01	0.01	A	0.02	0.02		A	0.14	0.14	
B	0.04	0.04	B		0.14		B		0.17	
C	0.07	0.07	C		0.17	0.17	C	0.21	0.21	
D	0.16	0.16	D	0.20	0.20		D	0.30	0.30	
E	0.34	0.34	E	0.23			E		0.33	0.33
F	0.46	0.46	F	0.26	0.26	0.26	F		0.35	0.35
G	0.60	0.60	G	0.32	0.32	0.32	G		0.38	0.38
H	0.70	0.70					H	0.44	0.44	0.44
I	0.75	0.75					I	0.49	0.49	
J	0.81	0.81					J	0.55	0.55	
K	1.00	1.00					K	0.62	0.62	0.62
							L	0.65	0.65	0.65
							M	0.71	0.71	
							N	0.74	0.74	
							O	0.78	0.78	
							P	0.83	0.83	
							Q	0.86	0.86	
							R	0.92	0.92	
							S	0.93	0.93	
							T	1.00	1.00	

3. SDS-PAGE analysis

While subjected to SDS-PAGE the male haemolymph showed the presence of sixteen clear and distinct bands while the female haemolymph revealed twenty bands (Fig. 3). The R_m values of the bands are presented in Table 1. The egg protein showed presence of six bands. The female haemolymph showed one protein band (R_m 0.17) that was absent in both egg and male haemolymph. The haemolymph band (R_m 0.55) was a thick band and perhaps it represented a composite band. On examination of the male haemolymph, female haemolymph and the egg proteins as revealed by SDS-PAGE showed that the egg and the female haemolymph proteins had three unique protein bands. The R_m values of such protein bands were 0.33, 0.35 and 0.38. Naturally it was evident that such protein bands were both egg and vitellogenic female-specific in nature which may perhaps be the vitellin proteins.

4. Determination of molecular weight of the female-specific proteins

SDS-PAGE along with molecular weight markers were subjected to electrophoresis. The usual SDS protein pattern was revealed (Fig. 4). Mobility of marker protein bands was plotted against log molecular weight and on that basis straight line was drawn. From that it came out that the molecular weight of the female-specific protein bands were 69.2 kD, 64.6 kD and 59.6 kD respectively.

DISCUSSION

In the present study both native as well as SDS-PAGE analyses have clearly shown that there are striking similarities between the protein components of male haemolymph, female haemolymph and egg. Native PAGE analysis of buffer extracted male and female haemolymph fails to show any difference. It clearly indicates that the soluble components are similar in both the cases, but while extracted with salt and detergent, the distinctions become apparent. The results (Fig. 2) clearly present this distinction. Obviously this distinction is due to the extraction of vitellogenin part in salt and detergent. This observation is strengthened by homologous presence of a band in the egg protein profile. Two female haemolymph-specific bands have been found in the present study of which one is not present in egg. Such predominantly female-specific protein has already been shown to be present in *Manduca sexta* (Ryan *et al.*, 1985). But such finding has not yet been made in any orthopteran insects.

In this study both native and SDS-PAGE studies have revealed the presence of vitellogenin protein in female haemolymph and egg extract. Native PAGE analysis of salt-detergent extract of egg shows this band as a very thick one while the other bands are very faint. This indicate that this is the main protein component in egg.

SDS-PAGE analysis has revealed three unique polypeptides in the egg as well as vitellogenic female haemolymph. Such finding indicates obvious relationship of these polypeptides with vitellogenin protein. Chinzei *et al.* (1981) first purified and studied the properties of vitellogenin in *Locusta*. They also showed the presence of a single unique band in native PAGE. Since then, a good number of other insects have been

studied to know these proteins and their properties. Chinzei *et al.* (1981) suggested that vitellogenin may be composed of 5–8 polypeptides with molecular weights ranging from 53–120 kD. In our present study the unique polypeptides possesses the molecular weights ~69.2 kD, 64.6 kD and 59.6 kD. Kanost *et al.* (1990) have reviewed the subject and indicated that vitellogenin may be composed either by two or three distinct polypeptides. In *Periplaneta* (Kim and Lee, 1994) two vitellogenins are present. In this study single protein has only been found. But it is sufficiently clear that is *Oxya* female-specific protein is present and it is perhaps composed of three polypeptides.

ACKNOWLEDGEMENT

Thanks are due to the authorities of ICAR and CSIR for financial assistance to continue this study.

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(Received in December 1998; revised and accepted in August 1999)

ENTOMON 25(2): 81–89 (2000)
Article No. ent.24402

Rearing of *Chrysoperla carnea* (Stephens) (Neuroptera : Chrysopidae) on Semi-synthetic Diet and its Predatory Efficiency Against Cotton Pests

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ABSTRACT: *Chrysoperla carnea* (Stephens) was reared for 10 successive generations on a larval semi-synthetic diet containing soybean hydrolysed powder (1.3%), egg yolk (32.3%), honey (16.1%), yeast extract (1.3%), water (38.7%), petroleum jelly (0.7%) and paraffin wax (9.6%). Biological parameters and predatory efficiency of *C. carnea* on *Helicoverpa armigera* (Hubner) and *Aphis gossypii* Glover were assessed in the laboratory and semi-field condition, respectively, and compared with predators reared on *Corcyra cephalonica* (Stainton) eggs. The development time was longer for semi-synthetic diet reared *C. carnea*. Mean adult emergence of *C. carnea* reared on semi-synthetic diet and reared on *C. cephalonica* eggs was 56.7 and 82.5%, respectively. Semi-synthetic diet reared larvae readily attacked and consumed cotton aphids, *A. gossypii* and eggs of *H. armigera*. Release of *C. carnea* at 1 : 50 (predatory-prey ratio) was found to be more effective in suppressing the aphid population than at 1 : 100 ratio.

KEYWORDS: Semi-synthetic diet, *Chrysoperla carnea*, *Corcyra cephalonica*, *Aphis gossypii*, *Helicoverpa armigera*, biological control.

INTRODUCTION

Chrysopids are important predators of several insect pests including aphids, lepidopteran eggs and larvae and other soft bodied insects (Hydorn and Whitecomb, 1979) and are widely recommended for augmentative biological control programmes against insect pests on cotton, tobacco, sunflower and groundnut (Singh and Jalali, 1991). The use of these entomophages requires their viability to rear in large numbers at lower costs for release against various pests. Currently, with the exception of some semi-synthetic diet rearing in Germany and USA, the large-scale production of chrysopids is done on factitious host eggs such as *Sitotroga cerealella* (Oliver), *Ephestia kuhniella* (Zeller) and *Corcyra cephalonica*. The difficulty in terms of cost and reliability

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of rearing two tropic levels of organisms to produce chrysopids justifies efforts to develop semi-synthetic diet based rearing system. Production of host insects in the laboratory is often seasonal which in turn affects the mass rearing of chrysopids. In the efforts to mass rear them, investigations on dietary requirements and semi-synthetic diets with varying degrees of success have been reported (Cohen and Smith, 1998; Hassen and Hagen, 1978; Gautam and Paul, 1987; Vanderzant, 1973; Pushpalatha *et al.*, 1994). Nevertheless, the purpose of this study was to develop a semi-synthetic diet using the most commonly available ingredients without using insect component for the rearing of *Chrysoperla carnea*. This approach would greatly help in mass rearing of *C. carnea* without depending on the factitious insects and enhance the potential for successful augmentative biological control programmes as well.

MATERIALS AND METHODS

Chrysoperla carnea culture was maintained on *C. cephalonica* eggs (irradiated with UV rays) by using multi-cellular tray and insects from this culture provided the initial stock for the semi-synthetic diet and for the *Corcyra* egg reared (control) predators. In the present studies, attempts were made to develop semi-synthetic diet using most commonly available ingredients in various proportions *viz.*, soybean powder (Soy Joy, Nilgiris Product), wheat germ powder (Wheatex, Nilgiris Product), soya meal (Himedia Product), aphid powder *(Aphis gossypii)*, ground *C. cephalonica* eggs, bovine serum albumin (Himedia product) and *Spodoptera litura* (Fabricius) abdomen powder. The senescent adults of *S. litura* and nymphs and adults of *A. gossypii* were killed by deep freezing (−5 °C) (abdomen alone was used in the case of *S. litura*) and dried in an oven at 100 °C for 90 to 120 minutes and powdered. *Corcyra* eggs were ground with water (1 : 5 ratio) and made as paste. Hydrolysed soybean powder was prepared by autoclaving freshly ground soya flour and water (1 : 4 ratio) at 15 kg/cm^2/30 min.

Composition of various semi-synthetic diets used in the study

1. Aphid (*Aphis gossypii*) powder (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
2. *Corcyra* egg paste (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
3. Bovine serum albumin (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
4. *Spodoptera* abdomen power (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
5. Soybean powder (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)

6. Hydrolysed soybean powder (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
7. Hydrolysed soybean powder (2.6%) + egg yolk (31.9%) + honey (15.9%) + yeast extract (1.3%) + water (38.2%) + petroleum jelly (0.6%) + paraffin wax (9.5%)
8. Hydrolysed soybean powder (3.8%) + egg yolk (31.5%) + honey (15.7%) + yeast extract (1.3%) + water (37.7%) + petroleum jelly (0.6%) + paraffin wax (9.4%)
9. Soya meal (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
10. Wheat germ powder (1.3%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
11. *Spodoptera* abdomen powder (0.6%) + hydrolysed soybean powder (0.6%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.8%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
12. Wheat germ powder (0.6%) + hydrolysed soybean powder (0.6%) + egg yolk (32.3%) + honey (16.1%) + yeast extract (1.3%) + water (38.8%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
13. Bovine serum (0.6%) + hydrolysed soybean powder (1.3%) + egg yolk (32.1%) + honey (16.0%) + yeast extract (1.3%) + water (38.5%) + petroleum jelly (0.6%) + paraffin wax (9.6%)
14. Bovine serum (0.6%) + hydrolysed soybean powder (0.6%) + wheat germ powder (0.6%) + egg yolk (32.1%) + honey (16.1%) + yeast extract (1.3%) + water (38.7%) + petroleum jelly (0.7%) + paraffin wax (9.6%)
15. Hydrolysed soybean powder (1.3%) + multivitamin (0.6%) + Vitamin E (0.6%) + egg yolk (31.9%) + honey (15.91%) + yeast extract (1.3%) + water (38.2%) + petroleum jelly (0.6%) + paraffin wax (9.5%)
16. Hydrolysed soybean powder (1.3%) + cholesterol (0.3%) + multivitamin (0.6%) + vitamin E (0.6%) + egg yolk (31.7%) + honey (15.9%) + yeast extract (1.3%) + water (38.1%) + petroleum jelly (0.6%) + paraffin wax (9.8%)
17. Control (eggs of *Corcyra cephalonica*)

The diet ingredients were mixed in a beaker and placed in a water bath at 50 °C. Petroleum jelly and paraffin was (Melting Point 52 °C) in the ratio of 1 : 16 were added to the diets to form a layer of about 5 mm to place them as capsules on polythene sheets which help in retaining moisture of the diets. Fresh capsules were provided every day to the larvae. The semi-synthetic diet was stored at 5–10 °C in the refrigerator and fresh diet was prepared once in a week. Two days-old larvae were taken for the experiment as they readily accepted the diet in our preliminary investigations. The larvae were kept in glass vials (4.5 × 2 cm) and plugged with absorbent cotton and the glass vials were changed once in 4 days. *C. carnea* adults reared on semi-synthetic diet and on

C. cephalonica eggs were provided with 30 per cent honey solution (in water), 50 per cent protinex (in water) and castor pollen grains.

During the semi-synthetic diet rearing process, the eggs hatch rate (%), larval duration, pupation rate and adult emergence (%) were recorded. Longevity and fecundity were recorded for both semi-synthetic diet and *Corcyra* egg reared adults. Weights of the one-day-old cocoons were taken on a Sartorius BP 210D balance. The experiment was replicated ten times and twenty-five *C. carnea* larvae were taken in each replication. ANOVA and *t* test was done to compare the efficacy of the diets for semi-synthetic diet rearing of *C. carnea*. The study was conducted at 26.5 ± 1 °C and 65% RH at the Project Directorate of Biological Control, Bangalore, India during 1996–98. Entire experiment was conducted under aseptic condition.

Studies on predatory efficiency

An experiment was conducted to test the feeding efficiency of semi-synthetic diet and *Corcyra* egg reared *C. carnea* on *Helicoverpa armigera* eggs in the laboratory. The number of eggs consumed by the larvae was recorded daily till pupation. The experiment was conducted in 10 replications and 25 larvae were taken in each replication. The *t* test was used for comparison of semi-synthetic diet and *Corcyra*-egg reared *C. carnea*. A study was also conducted to test the predatory efficiency of semi-synthetic diet and *Corcyra*-egg reared *C. carnea* against cotton aphid *Aphis gossypii* under semi-field condition. Cotton plants (Var. DCH 32) were infested by releasing the aphids in two different densities *viz.*, 50 and 100 (nos.)/plant. To determine the impact of *Chrysoperla*, the difference of post release aphid counts to pre-release aphid counts was taken. Two days-old larvae of *C. carnea* were released weekly as per the densities of the aphids in such a way that the ratio 1 : 50 and 1 : 100 were maintained. The study was conducted in 10 replications and *t* test was used for analysis of the data. Maximum care had been taken to eliminate other pests and natural enemies. The number of aphids/plant was observed weekly till harvest of the crop.

RESULTS AND DISCUSSION

Semi-synthetic diet rearing

The results recorded on the biology and biological attributes *viz.*, larval duration, pupation (%), pupal period (days), cocoon weight (mg), adult emergence (%), fecundity (nos./female) and longevity (days) of the predator on various semi-synthetic diets as compared to rearing on eggs of *C. cephalonica* are presented in Table 1. Among the various semi-synthetic diets tests for rearing of *C. carnea*, hydrolysed soybean based diet (diet no. 6) was found to be the best one with reference to increased pupation (84.5%), adult emergence (71%) and fecundity (440/females). However, these parameters (pupation, adult emergence and fecundity) were comparatively lower than the *Corcyra*-egg reared i.e. 86%, 79.3% and 448, respectively (Table 1). Larval duration on diet no. 6 was 14.5 days which was significantly lower than on other semi-synthetic diets but significantly higher than the *Corcyra*-egg reared at $P = 0.05$. Pupal

TABLE 1. Evaluation of various diets for mass rearing the larvae of *C. carnea*

Diet	Larval duration (days)	Pupation (%)	Pupal duration (days)	Cocoon weight (mg)	Adult emergence (%)	Fecundity (nos/♀)	Longevity (days)
1	32.17	10.00 (18.29)	7.67	3.47	2.50 (8.84)	12.00	27.00
2	19.00	31.80 (34.24)	7.67	3.87	13.00 (21.07)	132.0	45.00
3	19.40	38.17 (30.07)	12.50	3.88	13.10 (21.06)	50.0	32.00
4	17.20	31.67 (34.27)	7.62	4.47	56.17 (48.55)	16.0	50.00
5	17.07	75.80 (60.64)	8.17	3.40	49.17 (44.52)	103.0	41.00
6	14.57	84.50 (66.88)	7.45	4.23	71.00 (57.46)	440.0	76.67
7	29.03	49.17 (44.52)	10.80	4.07	32.50 (34.66)	338.0	69.00
8	25.05	57.10 (49.06)	10.18	4.15	39.00 (38.62)	259.0	68.00
9	21.75	88.33 (70.05)	8.28	4.32	58.50 (41.92)	433.0	66.33
10	29.07	67.17 (55.25)	10.48	3.92	38.80 (38.49)	355.0	62.00
11	16.77	82.00 (65.08)	7.63	3.88	57.83 (49.54)	98.0	48.00
12	20.50	58.67 (50.03)	10.88	4.00	12.67 (20.57)	184.0	66.33
13	35.05	11.25 (19.58)	11.08	3.78	20.00 (26.50)	184.0	72.67
14	32.05	45.00 (42.11)	12.83	3.93	27.50 (31.56)	125.0	65.67
15	38.90	55.17 (47.98)	9.50	3.98	6.00 (13.86)	125.0	13.00
16	33.00	43.00 (40.95)	9.08	4.08	8.00 (16.24)	140.0	42.00
17	9.00	86.00 (68.05)	6.50	8.90	79.30 (63.02)	448.0	85.67
S.Em ± 0.91		1.50	0.23	0.09	1.28	18.34	4.70
C.D (5%)2.58		4.23	0.65	0.25	3.60	52.84	13.55

Figures within parentheses are angular transformed values.
Note: Composition of diet 1 to 17 is given in material and methods.

duration of *Corcyra*-egg and semi-synthetic diet reared *C. carnea* varied from 6.5 to 12.8 and the lowest was recorded in *Corcyra*-egg reared followed by diet no. 6 (7.45). Fecundity of semi-synthetic diet and *Corcyra*-egg reared *C. carnea* ranged from 12.0 to 448 and the lowest and highest recorded from *Corcyra* egg-based diet and *Corcyra* egg reared respectively. There was no significant difference in fecundity of *C. carnea* reared on *Corcyra* egg (448), diet no. 6 i.e. soybean hydrolysed (440) and diet no. 9 i.e. soya meal (433). Pushpalatha *et al.* (1994) reported the possibility of using spent or dead *Spodoptera litura* adults abdomen based diet for the semi-synthetic rearing of *C. carnea*. In overall comparisons of all the semi-synthetic diets, hydrolysed soybean based diet (diet no. 6) was found to be the best one with reference to all the growth parameters. Hence the *C. carnea* was reared on the above diet for 10 generations in comparison with the rearing on eggs of *Corcyra*. There were no significant differences in per cent egg hatching between semi-synthetic diet and *Corcyra*-reared *C. carnea*. The larval period, per cent pupation, cocoon weight, per cent adult emergence and fecundity was significantly more in *Corcyra*-egg reared in comparison to semi-synthetic diet reared *C. carnea* (Table 2). The mean larval period (19.7 days) of the semi-synthetic diet reared *C. carnea* revealed that the predator develops slowly on the semi-synthetic diet. Differences in predator

TABLE 2. Comparisons of biology of semi-synthetic diet and *Corcyra*-egg reared *Chrysoperla carnea*

Growth parameters	Semi-synthetic diet reared	*Corcyra*-egg reared	*t* stat 5%
Egg hatch (%)	$89.60 + 0.28^a$	$89.90 + 0.23^a$	NS
Larval period (days)	$19.70 + 0.56^b$	$8.52 + 8.68^a$	19.75**
Pupation (%)	$76.10 + 1.30^b$	$87.30 + 0.39^a$	8.28**
Pupal period (days)	$8.46 + 0.19^a$	$8.68 + 8.78^a$	NS
Cocoon weight (mg)	$4.26 + 5.39^b$	$8.83 + 5.65^a$	58.26**
Adult emergence (%)	$56.66 + 1.99^b$	$82.34 + 0.42^a$	12.60**
Fecundity (nos./♀)	$254.0 + 17.12^b$	$324.24 + 12.15^a$	3.35**
Longevity (days)	$52.0 + 3.04^a$	$59.60 + 2.70^a$	NS

Analysis of variance was significant ($P < 0.05$). Means (+SEM) accompanied same letter not significantly different

performance on semi-synthetic diet and on *Corcyra* eggs may be related to nutritional quality of the prey and prey acceptance (De Clercq *et al.*, 1998). Semi-synthetic diet-reared predators were slightly inferior to those reared on natural or factitious insect (Cohen and Staten, 1994). Cohen and Smith (1998) have successfully reared *Chrysopa rufilabris* using beef liver and beef based semi-synthetic diet.

Laboratory studies on feeding potential of semi-synthetic diet and *Corcyra* egg reared *Chrysoperla carnea*

Semi-synthetic diet reared *C. carnea* readily accepted *H. armigera* eggs immediately after hatching as in the case of *Corcyra*-egg reared. Daily consumption of *H. armigera* eggs by the semi-synthetic diet reared *C. carnea* ranged from 5.9 to 148.6 and that of *Corcyra*-egg reared ranged from 3.9 to 148.8. There was difference in feeding efficiency of semi-synthetic diet and *Corcyra*-egg reared *C. carnea* till 5th day after hatching. The consumption rate of both semi-synthetic diet and *Corcyra*-egg reared was gradually increased from 5th day onwards and maximum (148.0) was recorded on 9th day after hatching. Again, consumption of eggs by semi-synthetic diet and *Corcyra*-egg reared *C. carnea* was decreased to 27.4 and 51.3 respectively. The mean daily and total consumption of *H. armigera* eggs by semi-synthetic diet and *Corcyra*-egg reared were 42.2; 422 and 45.4 and 454 eggs respectively and there was significant difference between semi-synthetic diet and *Corcyra*-egg reared *C. carnea* (Fig. 1) ($P = 0.01$). Sarode and Sonalkar (1998) reported that mean daily and total consumption of *C. carnea* reared on *C. cephalonica* eggs was 45.4 and 462 eggs respectively and the results were in conformity with our observations.

Field testing of semi-synthetic diet and *Corcyra* egg-reared *Chrysoperla carnea* against *Aphis gossypii* on cotton

In 1 : 50 predatory prey ratio, aphid infestation was found during third week of August 1997, on 40 days old crop and was present till November 1997. The initial

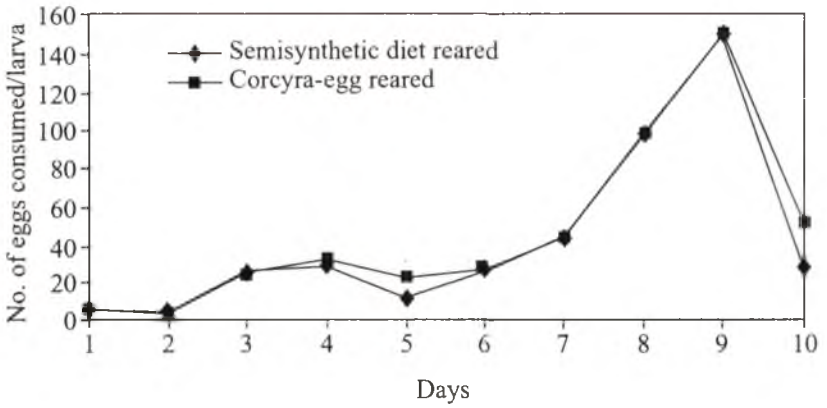

FIGURE 1. Feeding efficiency of semisynthetic diet and *Corcyra*-egg reared *C. carnea* on *H. armigera* eggs.

aphid population/plant in semi-synthetic diet reared, *Corcyra*-reared and controlled condition were 169, 222 and 110 respectively. After release of *C. carnea* larvae, the aphid population have come down in both semi-synthetic diet and *Corcyra* egg reared conditions where the aphid population in controlled condition shot up and reached its peak (2678/plant) by the end of October 1997 which affected the cotton plant severely. The aphid population in controlled conditions was 4 and 10 times higher than that of semi-synthetic diet and *Corcyra*-reared conditions respectively. Semi-synthetic diet and *Corcyra*-egg reared *C. carnea* larvae reduced the aphid population significantly in such a way that aphid population was 12 times lesser than that of control when the crop attained maturity. The mean aphid population/plant under semi-synthetic diet reared condition (240) was significantly less than that of control (763) and was significantly more than that of *Corcyra*-reared (190) ($P = 0.01$) (Fig. 2).

In 1 : 100 predator and prey ratio, aphid infestation was found during the second week of September 1997 and was present till November 1997. The initial aphid population/plant of semi-synthetic diet reared, *Corcyra*-egg reared and control was 304, 324 and 110 respectively. After the release of *C. carnea* aphid population has come down immediately both in semi-synthetic diet and *Corcyra*-reared conditions similar to 1 : 50 condition. However, aphid population in control reached to the peak during the third week of October 1997 which was 7.6 and 9.7 times higher than that of *Corcyra*-egg and semi-synthetic diet reared conditions. During the maturity of the crop, the aphid population in control was 9 times higher than that of semi-synthetic diet reared. The mean aphid population per plant in semi-synthetic diet reared (324) conditions was significantly lower than that of control (888) and significantly higher than that of *Corcyra*-egg reared (302) ($P = 0.01$) (Fig. 3). Release of syrphids at 1 : 100 ratio was found to be ideal for controlling *Brevicoryne brassicae* Linnaeus and *Aphis pomi* de G. (Starka, 1976; Wunk, 1977). Our studies revealed that both semi-synthetic diet and *Corcyra*-egg reared *C. carnea* were effective in suppressing

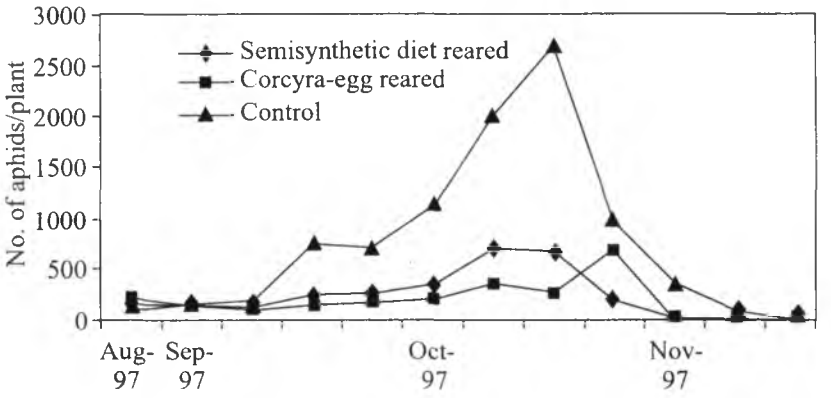

FIGURE 2. Predatory efficiency of semisynthetic diet and *Corcyra*-egg reared *C. carnea* against cotton aphid, *A. gossypii* (Predatory:Prey ratio 1 : 50).

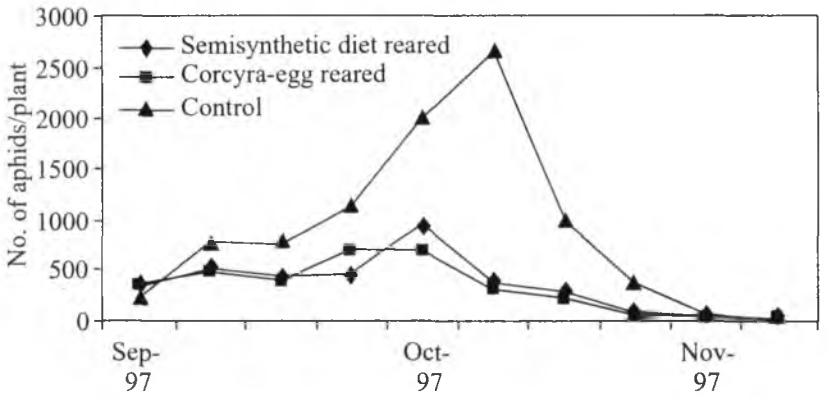

FIGURE 3. Predatory efficiency of semisynthetic diet and *Corcyra*-egg reared *C. carnea* against cotton aphid, *A. gossypii* (Predatory : Prey ratio 1 : 100).

aphid population when released at 1 : 50 and 1 : 100 ratio. However, the ratio 1 : 50 was found to be ideal as the release of higher number of chrysopids could suppress the sudden increase of aphid population. Jalali and Singh (1994) reported that the chrysopid *Mallada astur* larvae consumed significantly more *A. gossypii* than *Cheilomenes sexmaculata* (Fabricius) larvae. Further, Ragnhild (1966) found that *Chrysopa carnea* was able to consume highest number of *Myzus persicae* (Sulzer) when compared to *Coccinella septempunctata* and *Syrphus ribessi* Linnaeus. Hence, it is suggested that further improvement of the nutritive value, formulation of the semi-synthetic diet and automation techniques may increase the practical value of the semi-synthetic diet mass rearing techniques of *C. carnea*.

ACKNOWLEDGEMENTS

Thanks are due to Mr. Birendra Kumar Chaubey, T-4, for his technical assistance and Mr. S. R. Biswas, Statistian for statistical analysis.

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(Received in March 2000; revised and accepted in May 2000)

ENTOMON 25(2): 91–96 (2000)
Article No. ent.25203

Incidence of Black Scale Insects (*Saissetia nigra*, N.) Infesting Mulberry in Kanakapura Taluk (Bangalore Rural District, Karnataka State)

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ABSTRACT: Kanakapura Taluk in Bangalore rural district is one of the most leading place in Karnataka State practicing sericulture. The total area under mulberry cultivation is about 6817.76 hectares, of this, 6812.46 hectares are under irrigated conditions. Black scale insects suck the cell sap and kill the plants. The surface of the attacked stems are covered all over with scales. The lenticels are completely hidden, and so respiratory and lenticular transpiration rate of the plant cells are considerably lowered. In the present study, an extensive survey for two years (July 1995 to June 1997) at monthly intervals on the infestation of black scale insects on mulberry plants (Kanva2 or M5 variety) in twenty villages of Kanakapura taluk was undertaken. The data revealed that the infestation by black scale insects was maximum in the month of December and January while it was minimum in the months of May and July. Infestation was not seen in the months of October and February. There was significant negative relationship between the infestation and climatic factors *viz.*, Temperature (maximum) and Relative humidity whereas Rainfall was not significant.

KEYWORDS: Black scale insects, Incidence, Mulberry, Survey.

INTRODUCTION

The incidence of black scale insects (*Saissetia nigra*, N.) (Hemiptera : Coccidae) is more prevalent in hilly regions of India. Almost all species of hard and soft scales that attack mulberry enter into diapause to avoid extreme cold under temperate conditions but in tropical species diapause is not common. However, during dry season or cold weather the population declines. The period of their occurrence in Bangladesh, India and Vietnam is in warmer months. The surface of the attacked stem are covered all over with scale insects. The mulberry shoots infested by black scale express the symptoms of yellowing or mottling of leaf blade. Such infested branches also start dying gradually from the distal end (Sengupta *et al.*, 1990). Black scale insects have their life cycle dependent on the host rather than on temperature (Flander, 1939).

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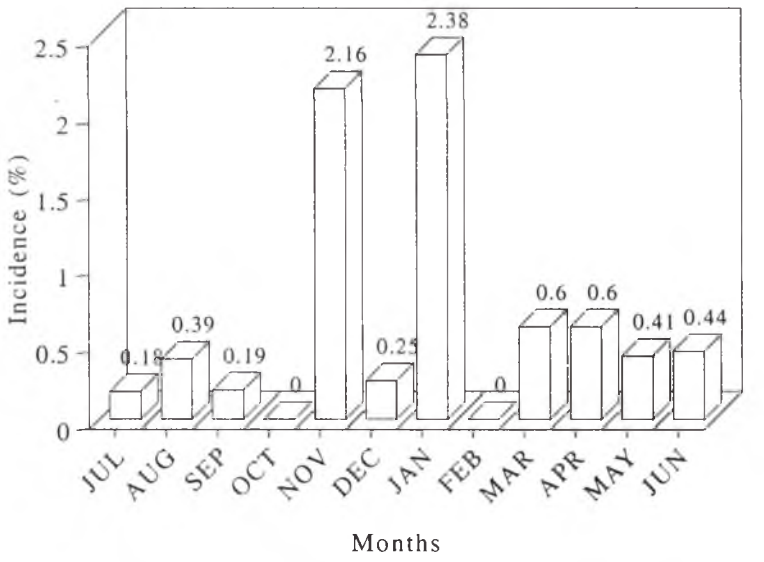

FIGURE 1. Incidence (%) of Scale insects in 20 villages of Kanakapura Taluk during July 1995 to June 1996.

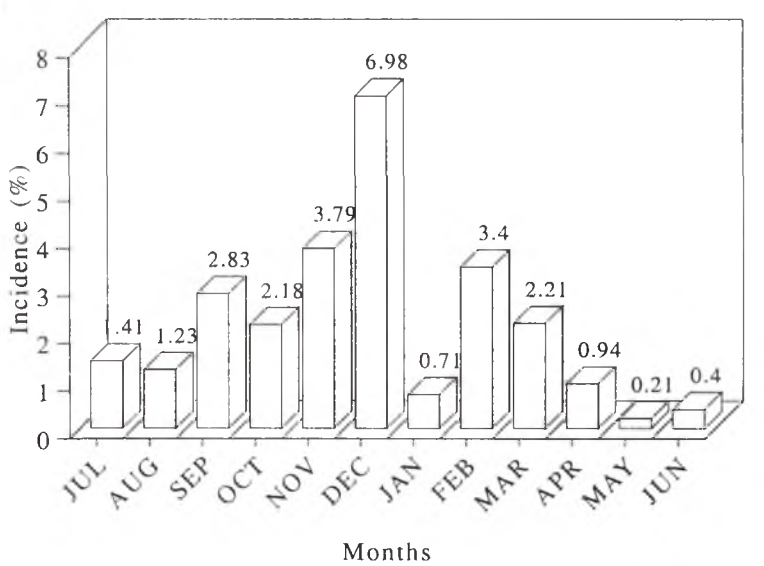

FIGURE 2. Incidence (%) of Scale insects in 20 villages of Kanakapura Taluk during July 1996 to June 1997.

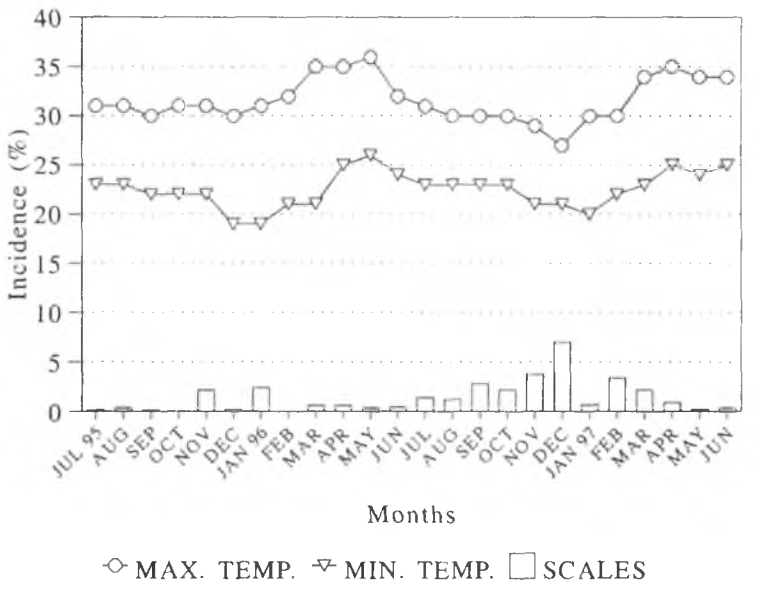

FIGURE 3. Incidence (%) of Scale insects in relation to temperature in 20 villages of Kanakapura Taluk from July 95 to June 97.

The scale insects suck the cell sap and kill the plants, the surface of the attacked stems were covered all over with scales (Rangaswami *et al.*, 1976). In Italy, the insects complete three generations per year. So far, 26 species have been reported to occur on mulberry in the world. Pakistan represents the major fauna of scale insects (13 species) followed by India (9 species), Japan (6 species), USA (5 species) and Israel (4 species) (Bhattaglia *et al.*, 1984). By comparing their incidence and intensity on agricultural crops, economic loss can be calculated from survey conducted (Gunashekaran and Govindaiah, 1993). Kanakapura taluk in Bangalore rural district is one of the most leading area practicing sericulture in Karnataka state. Total are under mulberry cultivation is about 6817.76 hectares, of this, 6812.46 hectares area under irrigated condition. Hence, an attempt was made to understand the severity of *Sassetia nigra* infestation on mulberry plants as they form the sole food material of the silk worms—*Bombyx mori* L.

MATERIALS AND METHODS

Survey on the incidence of black scale insects was carried out by fixed plot method during July 1995 to June 1997 at monthly intervals in 20 villages of Kanakapura taluk (Bangalore rural, district, Karnataka state) namely, Harihara, Bhoovahally, Kadahally, Murlethimmana doddi, Boregowdana doddi, Sathanur, Saslapura, Dhalimba, Kabbalu,

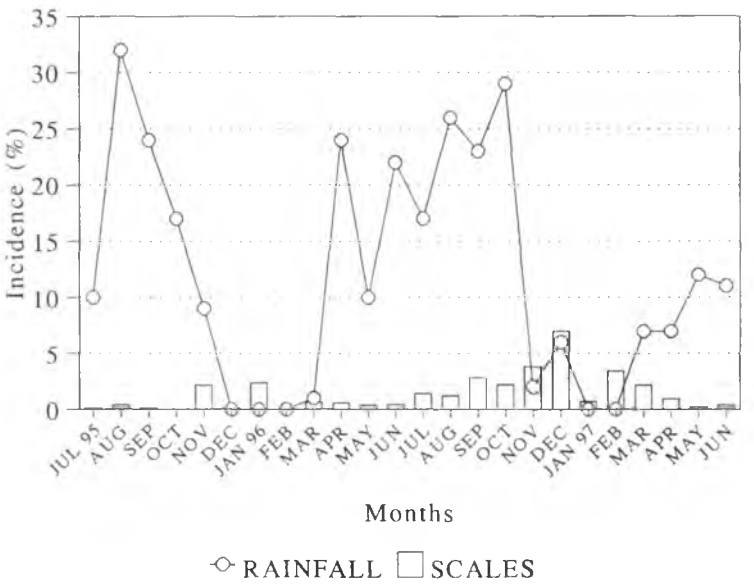

FIGURE 4. Incidence (%) of Scale insects in relation to Rainfall in 20 villages of Kanakapura Taluk from July 95 to June 97.

Kalegowdana doddi, Thotahally, Nayakanahally, Doddaalahally, Krishnaiahna doddi, Settekere doddi, Subkere, Chatra, Thungani, Hanumanahally and Harohally. The procedure outlined by Chandrakala (1995) was adopted for conducting the survey. In each village, four mulberry gardens were chosen. In each mulberry garden, five microplots were considered (four at corners and one in the middle of the garden). Twenty randomly selected plants in each microplot were observed for pest infestation (100 plants per garden). The incidence of black scale insects was calculated using the following formula:

$$\text{Percentage of Pest Infestation (PPI)} = \frac{\text{Total No. of infested plants}}{\text{Total No. of plants surveyed}} \times 100$$

Certain physical factors *viz.*, temperature, rainfall and relative humidity that prevalied during the course of study (July 1995 to June 1997) were also recorded to assess their influence on the incidence of black scale insects. The data were statistically analysed using 'F' test (Asthana and Srivastava, 1967).

RESULTS AND DISCUSSION

The findings of the filed study are indicated in Figs 1–5 and Table 1. Heavy infestation by black scale insects was in the month of January 1996 (2.39%) and December

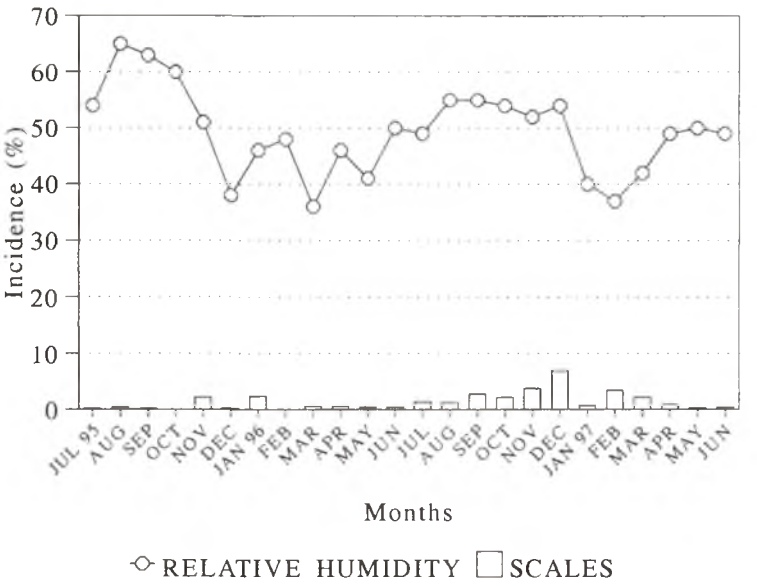

FIGURE 5. Incidence (%) of Scale insects in relation to Relative Humidity in 20 villages of Kanakapura Taluk from July 95 to June 97.

TABLE 1. Correlation between incidence of black scale insects and physical factors

	Maximum temperature	Minimum temperature	Rainfall	Relative humidity
Incidence of black scale insects (%)	−0.5104*	−0.2903	−0.1813	−0.5039*

**Significant at 0.001 level; *Significant at 5% level.

1996 (6.98%) when the average maximum and minimum temperature, rainfall and relative humidity was 31–27 °C, 21–19 °C, 0–6 mm, 46–54% respectively while it was minimum and negligible in the month of July 1995 (0.18%) and May 1997 (0.21%) when the average maximum and minimum temperature, rainfall and relative humidity was 31–30 °C, 23–22 °C, 10–17 mm, 54–60% respectively. Infestation was not seen in the months of October 1995 and February 1996 when the average maximum and minimum temperature, rainfall and relative humidity was 32–31 °C, 22–21 °C, 0–17 mm, 48–60% respectively (Figs 1 and 2).

The correlation coefficients between the incidence of scale insects and the physical factors of the environment *viz.*, temperature (maximum and minimum), rainfall and

relative humidity are presented in Table 1 and Figs 3–5. There was a significant negative correlation with maximum temperature (−0.51) and relative humidity (−0.50) where as no significant correlation was observed with reference to rainfall.

The Black scale insects were found to have a life cycle dependent on the host rather than on temperature (Flander, 1939). *Saissetia nigra* N. was found to be more prevalent in hilly regions of India, especially on large and medium sized trees and very rarely on bushes (Rangaswami *et al.*, 1976). Black scale insects were more prevalent in hilly regions of India, the period of their occurrence in Bangladesh, India Vietnam was in the warmer months (Sengupta *et al.*, 1990). Almost all species of hard and soft scales that attack mulberry enter into diapause to avoid extreme cold under temperate conditions but in tropical species diapause is not common. However, during dry season or cold weather the population declined depending on the species (Narayan Swamy and Reddy, 1997). In the present study the incidence of black scale insects was maximum in the months of December and January, while it was minimum in the months of May and July. Infestation was not seen in the months of October and February.

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(Received in September 1999; revised and accepted in April 2000)

ENTOMON 25(2): 97–101 (2000)
Article No. ent.25204

Studies on Ants (Formicidae) of Rajasthan - III. Banswara

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ABSTRACT: Ants were collected from various localities of Banswara District from ground, tree trunks, under store and near roofs of trees. Six species of Formicidae were collected and three of them were new species.

KEYWORDS: Ants, Banswara, Rajasthan.

INTRODUCTION

The author in her first paper on series of Rajasthan ants dealt with the ants of Jodhpur, second paper on series of Rajasthan ants of Dungarpur. This is the third paper on series of Rajasthan ants in which ants of Banswara are reported.

The district Banswara(bans-bamboo trees) lies in the southern region of Rajasthan state between latitude 23°11′ and 23° 56′ N and longitude 74° 00′ and 74° 47′ E. Its maximum length from north to south is about 93 Kms and maximum breadth from east to west is 83 Kms.

It is bounded by Udaipur and Chittorgarh districts in the north and north-east respectively by Madhya Pradesh state in the east to west.

The district is quadrangular in shape and fairly open in the west but it is undulating in nature. The central and western portions of the district are however, cultivation plains. There are scattered ranges of Aravallis in the eastern half of the district, but none of them is of great height.

There are some miscellaneous species of bamboo trees (*Dendrocalcanus strictus*) and Khajur trees (*Phoenix sylvestris*).

The forests of the Banswara district consists mainly of teak, situated on the slope of Aravalli hills and undulating terrain. Inspite of ants being so common very little information is available on them specially from north-west India.

Bingham's (1903) Fauna is the main source of knowledge on ants of India. Chapman and Capco (1951) published a Checklist of Ants of Asia. Chhotani and Ray (1976) dealt with a few species of ants of desert region of Rajasthan. Since then no one has worked on the ants of Rajasthan.

The author prepared a paper on studies on ants (Formicidae) of Rajasthan - I.

Jodhpur (1995) and reported some species of ants of Jodhpur region. She with Rathore (1996) has also worked out the Ant (Formicidae) Fauna of Thar Desert.

Ants were collected from various localities of Banswara district from ground, tree trunks, under stone and near roots of trees.

Six species of Formicidae were collected from different localities of Banswara pertaining to two sub-families *viz.*, Formicinae and Myrmicinae. Out of six species three are new record from Rajasthan.

A zoogeographical analysis shows that one species is Universal, three are restricted to Indian sub-continent and two are endemic to India.

Abbreviations used P. C. Tak - P.C.T.; N. S. Rathore - N.S.R.

Ants have three distinct forms - the fertile female (♀), the male (♂) and a worker ☿ major or minior). The largest forms of workers are soldiers.

The identification key is based on the worker caste of an ant ☿.

Key to the sub-families of Family Formicidae.

A. Pedicel of the abdomen one-jointed S. F. Formicinae
B. Pedicel of the abdomen two-jointed S. F. Myrmicinae

A. Sub-family Formicinae Lepeletier

(i) Tribe Oecophyllini Forel

Oecophylla Smith

Oecophylla smaragdina (Fabricius)

Oecophylla smaragdina, (Fabr.) (*Formica*) *Syst. Ent.* (1775): 828: ♀: Forel, *J. Bombay nat. Hist. Soc.*, 8 (1894): 400.

Material Many exs, N.C.R., 24.8.84; 15 exs, N.C.R., 26.8.84; 10 exs, N.C.R., 28.8.84; 15 exs, P.C.T., 23. 5. 87; 7 exs, P.C.T., 26.5.87.
From ground, mango tree trunk, mango tree roots.

Diagnostic characters Length ☿ maj. – 9.5–11 mm.; Length ☿ min. – 7–8 mm.

Rusty red, Head of ☿ maj. and ☿ min. relatively of the same size, roundly qudrangular, posteriorly not emarginate. Mandibles long, with masticatory margin very broad in proportion to the length, dentate, the apical tooth acute and curved. Maxillary palpi 5-jointed. Antennae 12-jointed. Thorax elongate, pronotum convex anteriorly, narrowed into a collar, mesonotum constricted narrow, viewed sideways saddle shaped. Pedicel elongate, incrassate in the middle, scarcely nodiform.

Distribution Rajasthan: Banswara.

Range Throughout India. Myanmar, Sri-Lanka.

Remarks

Recorded for the first time from Rajasthan. This is the notorious ant commonly called as 'Red Ant' of India. It is found in the hilly areas having wetter climate and is never

found in hot dry plains of desert areas of Rajasthan. This species inhabits trees and makes nest of leaves.

(ii) Tribe Plagiolepidini Forel

Plagiolepis Mayr

Plagiolepis jerdoni Forel, *J. Bombay nat. Hist. Soc.*, 8 (1894): 415–416 ☿.

Material 10 exs, N.C.R., 8.9.86 understone.
Diagnostic characters Length ☿ - 1.5 mm.

Brownish black, head smooth, polished and shining. Frontal area distinct. Maxillary palpi 6-jointed. Mandibles narrow, masticatory margin with five teeth, the apical tooth long and acute. antennae 11-jointed, slender extending slightly more beyond the top of the head. Thorax short and broad, pronotum large, convex, mesonotum from above circular and convex, mesometanotal emargination well marked. Metanotum and node of pedicel without spines. Node of the pedicel low, strongly inclined to the front.

Distribution Rajasthan - Dungarpur

Range Western India, Karnataka, Kerala, Poona distt. - Kanara, Travancore.

B. Sub-family Myrmicinae Lepeletier

(i) Tribe Pheidolini Emery

Messor Forcel

Messor himalayanum Forcel

Stennama (Messor) barbarum, race *himalayanum*, Forcel, *Rev. Suisse zool.* 10 (1902): 220.

Material Many exs, N. s. R., 8.9.86 From ground.
Diagnostic characters Length - ☿ - 4–10 mm.

Black ant with abundant pilosity. Posterior margin of clypeus produced between basis of antennae. Mandibles massive, the outer margin strongly curved, the masticatory margin dentate, the inner margin very thick, concave above. Flagellum of antennae scarcely thickened towards apex without a distinct club. Thorax narrower than the head, pronotum rounded in front, the mesonotum raised anteriorly steeply sloped, pro-mesonotal suture distinct, meso-metanotal suture deeply marked. Metanotum bidentate, 1st node of pedicel conical, rounded above, the front face concave furnished with a long petiole, 2nd node broader,rounded above, about as broad as long.

Distribution Rajasthan - Banswara, Bundi, Bikaner, Gudha, Jodhpur, Kishangarh.

Range Punjab - Chandigarh, the north-west Himalayas, Dharmsala, the Tons Valley, Quetta.

(ii) Tribe Solenopsidini Forel

Monomorium Mayr

Monomorium sagei Forel

Monomorium sagei, Forel, *Rev. Suisse Zool.* 10 (1902): 211

Material 10 exs, N.C.R., 24.8.84; 20 exs, N.C.R., 27.8.84. Ground, mango tree roots.
Diagnostic characters Length ♀ - 2.2–2.5 mm.

Pale yellow, smooth and shining. Mandible narrow with four acute teeth. Antennae 12-jointed, scape extending beyond the top of head, flagellum with a distinct club. Thorax convex above not submargined, thorax seen in profile deeply emarginate at the meso-metanotal suture. Pedicel - the 1st node squamiform, anteriorly petiolate, 2nd node from above circular, smoothly rounded a little broader in front than posteriorly, abdomen more than twice as long as broad.

Distribution Rajasthan – Banswara

Range North-west Himalayas. Dharmsala

Remarks

Recorded for the first time from Rajasthan.

Monomorium (Xeromyrmex) indicum Forel *Monomorium salomonis*, Linn. race *indicum*, Forcel, *Rev. Suisse Zool.* 10 (1902): 213.

Monomorium (Xeromyrmex) salomonis sub sp. *indica*; Emery, C., *Gen. Insect. Fasc.* 174 B (1922): 178

Material Many exs, N.C.R., 28.8.84 From Palm tree trunk.
Diagnostic characters Length - ♀ 2.5–3.5 mm.

Ferruginous red with abdomen dark brown. Head more or less rugulose, opaque, distinctly broader in front than posteriorly. Mandibly when partially closed, concealed under the protecting margin of the clypeus, narrow with four acute teeth. The scape of flagellum not attaining the posterior margin of the head. The thorax in profile emarginate at the suture, the meso-metanotal suture distinct. Petiole - seen from above both nodes equal, the rounded 1st node higher than the 2nd and petiolate anteriorly.

Distribution Rajasthan - Banswara, Jodhpur, Kolayat, Korsina, Kotra, Nokha.

Range Throughout India. Myanmar.

Monomorium (Xeromyrmex) longi Forel. *Monomorium (Xeromyrmex) longi* Forel, *Rev. Suisse Zool.* 10 (1902): 211.

Material 15 exs, N.C.R., 28.8.84 Pal tree trunk.
Diagnostic characters Length - ♀ - 2.5 mm.

Dull chestnut brown. Head more or less rugulose, opaque. Mandibles opaque with four

teeth. antennae long, scape reaching beyond the top of the head. Thorax long, pro-mesonotum very convex, meso-metanotal suture well marked, the thorax emarginate at the suture, the metanotum rectangular, sub-margined at base sloping to the meso-metanotal suture. Pedicel - the 1st node rounded at the apex petiolate anteriorly, 2nd node globose.

Distribution Rajasthan - Banswara

Range Assam, Chandigarh

Remarks

Recorded for the first time from Rajasthan.

Zoological analysis of ant fauna of Banswara

Universal	Indian Sub-continent	Endemic
1. *Oecophylla smaragdina* Fabr.	1. *Messor himalayanus* Forel 2. *Monomorium sagei* Forel 3. *Monomorium (Xeromyrmex) indicum* Forel	1. *Plagiolepis jerdoni* Forel 2. *Monomorium (Xeromyrmex) longi* Forel

ACKNOWLEDGEMENT

Gratitude is expressed towards Dr. Q. H. Baqri, Officer-in-Charge, D.R.S., Z.S.I., Jodhpur for providing facilities and for advice to improve the quality of the communication. I am grateful to Prof. Ishwar Prakash who went through the manuscript and gave useful suggestions. I am also thankful to Dr. A. K. Ghosh, Director, Zoological Survey of India, Calcutta for support to my research work.

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(Received in March 1999; revised and accepted in October 1999)

ENTOMON 25(2): 103–105 (2000)
Article No. ent.25205

Distribution of Adult workers and Soldiers in Different Parts of the Mounds of the Termite *Odontotermes Obesus* (Rambur) (Isoptera : Termitidae)

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ABSTRACT: Mound nests of the termite *Odontotermes obesus* of different heights were surveyed in the vicinity of Karnatak University, Dharwad. Such mound nests were vertically cut open, the entire royal chamber was taken out and total number of adult workers and soldiers were counted. Total number of workers and soldiers of different sizes were also determined from each unit (50 gm) of fungus comb from the central and peripheral regions of the mound nest.

Differential distribution of adult workers and soldiers in different parts of the mound nests of the termite *O. obesus* is attributed for the different functional behaviour.

KEYWORDS: *Odontotermes obesus*, workers, soldiers, fungus comb, royal chamber.

INTRODUCTION

The population size is an important requisite in the evaluation of the role of organism in the dynamics of an ecosystem (Easey and Holt, 1989). Total population of various castes and their relative percentage in different species of termites have been studied by Holdaway *et al.* (1935) in *Eutermes exitiosus*, Gay and Greaves (1940) in *Coptotermes lacteus*, Mukherjee and Mitra (1949) in *O. redemanni*, Gupta (1953) in *O. obesus*, Sen-Sarma and Mishra (1969) in *Microtermes beesoni*, Gay and Wetherly (1970) in *Nasutitermes exitiosus*, Mallisse *et al.* (1975) in *neotermes exitiosus* and Darlington (1987, 1990) in *Macrotermes subhyalinus*. The total population and relative percentage of the foraging forms have been studied by Veeranna and Basalingappa (1982) in *O. wallonensis*. Function based distribution of workers and soldiers in different parts of the mound nests of *O. wallonensis* has been reported by Veeranna and Basalingappa (1983), Patil and Basalingappa (1993) in *O. brunneus* and Darlington (1987) in *Macrotermes subhyalinus*. The present investigation was undertaken to study the population density and relative percentage of different sized

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TABLE 1. Distribution and percentage of different sized adult workers and soldiers from the royal chambers of the termite *O. obesus*

Average number of termite from the royal chamber	Number and percentage of different sized termite				
	Adult workers			Adult soldiers	
	2 mm	3 mm	4 mm	3 mm	4 mm
1623.03	81.23 ±26.47 (5.00)*	339.87 ±16.78 (6.18)	100.30 ±16.78 (6.18)	41.23 ±13.77 (2.54)	1060.40 ±231.18 (65.33)

*Figures in parantheses are the percent values of different sized workers and soldiers.

adult workers and soldiers from different parts of the mound nests of the termite *O. obesus*.

MATERIALS AND METHODS

Termite mounds were surveyed in the vicinity of Karnatak University campus, Dharwad in the month of Jan–April 1995. On the basis of their height ranging from 18–150 cm, 25 mound nests were selected to study the distribution of total number of adult workers and soldiers from the fungus comb from the different parts of the mound.

Termite mound nests, one at a time were cut open vertically, five samples of fungus comb (each of 50 gm) from peripheral and central parts of the mound were collected into separate polythene bag. Intact royal chamber was carefully removed out of the mound, brought to the laboratory, cut open carefully, sorted out the workers and soldiers and recorded their number (Table 1). Further, various sized adult workers and soldiers were isolated from the fungus comb from peripheral and central region an also from royal chamber. Measurements of individual workers and soldiers were taken and recorded under different size group. Average values of the number and percentage of workers and soldiers of different sizes from five samples of fungus comb were calculated for each mound nest.

RESULTS AND DISCUSSION

Average values of population density of workers and soldiers of termite *O. obesus* from each unit of fungus comb form different parts of the mound nests *viz.*, peripheral and central parts of the mound nest and from the royal chamber were as presented in Tables 1 & 2. The higher percentage of workers in the royal chamber is attributed for the purpose of feeding the royal couple and for transporting the eggs from the royal chamber to fungus comb for incubation, whereas, higher percentage soldiers in the royal camber was meant for guarding the royal couple. Results revealed that different sized workers and soldiers from different parts of the fungus comb and royal chamber of the mound nests were distributed according to their functional behaviour.

TABLE 2. Distribution and percentage of different sized adult workers and soldiers from each unit of fungus comb form peripheral and central parts of mound of the termite *O. obesus*

Ave population density of termite /unit (50 gm) fungus comb	Number and percentage of different sized termite				
	Adult workers			Adult soldiers	
	2 mm	3 mm	4 mm	3 mm	4 mm
Peripheral 263.30	20.16 ±8.40 (7.66)	94.05 24.86 (35.72)	109.0 ±0.33 (0.35)	0.93 ±0.33 (0.35)	39.07 ±3.09 (14.84)
Central 385.71	41.31 ±7.58 (10.71)	158.80 ±30.95 (41.71)	112.30 ±20.03 (29.11)	1.71 ±0.53 (0.44)	71.59 ±4.46 (18.56)

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(Received in October 1999; revised and accepted in May 2000)

ENTOMON 25(2): 107–115 (2000)
Article No. ent.25206

Effect of Plant Oils on the Haemolymph Proteins of Final Instar Larvae of *Helicoverpa armigera* Hubner

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ABSTRACT: A study on the effect of three plant oils *viz.*, *Artemisia annua* Linn., *Ageratum conyzoides* Linn. and *Azadirachta indica* A. Juss. on the haemolymph proteins of final instar larvae of *Helicoverpa armigera* Hubner was undertaken by topically treating the larvae on the dorsal side of the mesothoracic region at their ED_{50} (effective dose) values of 1763.39, 3280 and 753.80 $\mu g\ g^{-1}$ body weight, respectively. The overall mean protein concentration of *Artemisia* (106.9 mg ml^{-1}), *Ageratum* (86.5 mg ml^{-1}) and *Azadirachta* (126.5 mg ml^{-1}) oil treated larvae was significantly lower than that of control larvae (210.5 mg ml^{-1}) and its build up was delayed. All of three plant oils affected the number and prominence of the major protein bands in the electrophoretic protein profiles of haemolymph. The synthesis of storage protein (84.1 kDa) was delayed. The absence or late appearance of some proteins in treated insects suggest the interference of the three oils with protein synthesis.

KEYWORDS: *Artemisia annua, Ageratum conyzoides, Azadirachta indica, Helicoverpa armigera* and haemolymph proteins.

INTRODUCTION

One of the most striking features of the development of holometabolous insects is the synthesis of a quantitatively significant class of polypeptides known as storage proteins (Thomson, 1975; Wyatt and Pan, 1978). These proteins comprise the bulk of the polypeptides in larval haemolymph constituting about 80% of total haemolymph proteins which are characterized by exceptionally high content of aromatic aminoacids *viz.*, tyrosine and phenylalanine (Wyatt and Pan, 1978). The insect storage proteins are high molecular weight multimers, usually hexamers, composed of subunits in the molecular mass range of 70–90 kDa (Haunerland, 1996). The storage proteins appear to be special adaptation to insect moulting, metamorphosis and reproduction. Fat body (Palli and Locke, 1988) epidermis, midgut (Palli and Locke, 1987) and pericardial cells (Fife *et al.*, 1987) contribute to the haemolymph protein pool. The *Artemisia annua* oil treatment decreased haemolymph protein concentration and distributed its

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electrophoretic protein pattern of haemolymph of *Dysdercus koenigii* F. (Rao *et al.*, 1999). Significant reduction in storage protein was observed in azadirachtin treated *Spodoptera litura* (Rao *et al.*, 1996).

In the present investigation, the effect of plant oils *viz.*, *Artemisia annua* Linn., *Ageratum conyzoides* Linn. and *Azadirachta indica* A.Juss on the haemolymph protein of final instar larvae of *Helicoverpa armigera* Hubner were studied both quantitatively and qualitatively.

MATERIALS AND METHODS

Ageratum conyzoides was collected during the months of March-April from campus of Indian Agricultural Research Institute (I.A.R.I), NewDelhi. Freshly collected plants were cut into pieces and hydrodistilled. The distillate was repeatedly extracted with dichlomethane. The ogganic part was sepatated and the solvent was evaporated *in vacuuo* to give a red coloured essential oil. *Artemisia annua* oil was a gift from Prof. S. K. Sinha former Director, I.A.R.I for bioactivity testing. *Azadirachta indica* oil was provided by Dr. C. Devakumar, Division of Agricultural Chemicals, I.A.R.I., which was extracted from neem seed kernals using hexane solvent.

Field collected larvae of *H. armigera* were reared on a semi-synthetic diet modified after Nagarkatti and Prakash (1974) in the laboratory at a temperature of 27 ± 1 °C and a relative humidity of $60 \pm 10\%$. The photoperiod in the culture room was maintained at 14 h Light (05.00–19.00 h) and 10 h Dark (19.00–05.00 h) using fluorescent tubes (20W) connected to an automatic timer. The fifth-instar larvae (0–12 h old) of *H. armigera* were topically treated with effective doses (ED_{50}) of 1763.39, 3280.30, and 753.80 $\mu g\ g^{-1}$ body weight, respectively for *A. annua, A. conyzoides* and *A. indica* oils. The effective dose based on 50 per cent normal adult emergence was calculated using probit analysis (Finney, 1981). The ED_{50} of three oils were treated topically by applying on the dorsal side of the mesothoracic region using a 50 μl precalibrated Hamilton syringe mounted on a programmable microapplicator (Stoelting Autogenic Systems, U.S.A.).

Collection and processing of haemolymph

The haemolymph was collected from 10 larvae of each treatment separately at 24 h, 48 h, 72 h, 96 h and 120 h after the treatment. The haemolymph was drawn by pricking the second proleg of the larva with a sterilized needle and collected into prechilled eppendorf vial having few crystals of phenyl thiocarbamide (1-phenyl-2-thiourea). Haemolymph from 10 larvae was pooled which constituted a replication. Minimum of three such replications were maintained. The sample was centrifuged in refrigerated centrifuge at 10,000 rpm for 10 min at 4 °C to sediment the haemolymph and to get clear plasma. The plasma was stored at −20 °C till further use.

Quantitative estimation of proteins

Protein content of haemolymph was estimated according to Lowry *et al.* (1951), using bovine serum albumin (BSA) as the standard (Fig. 1).

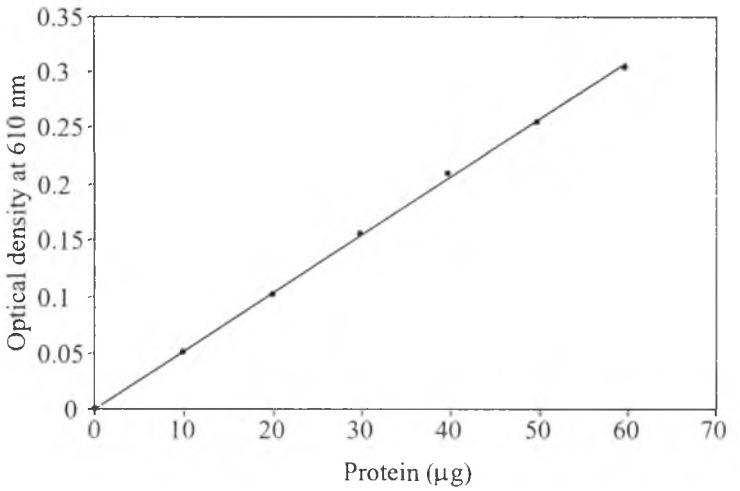

FIGURE 1. Standard graph for Protein.

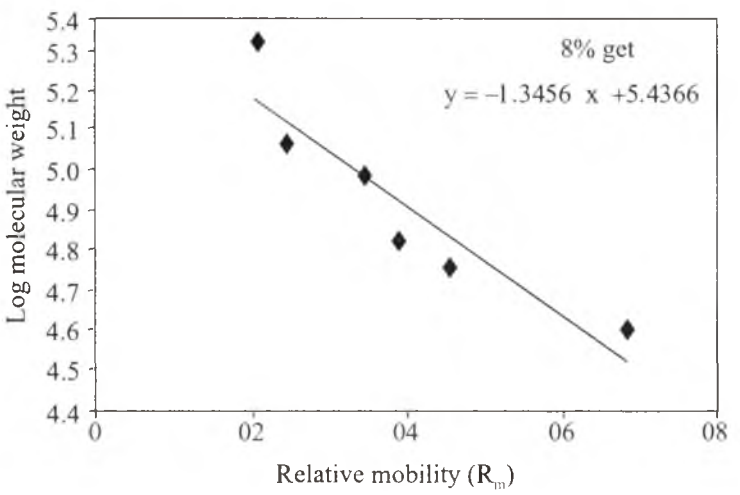

FIGURE 2. Standard graph for determination of protein molecular weights.

Haemolymph protein profile

The electrophoretic protein profile of haemolymph was determined by one-dimensional sodium-dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) using a vertical slab gel electrophoresis unit (Hoefer Scientific Instrument attached to a power supply (LKB-2297 Macrodrive 5) as detailed by Laemmli (1970).

A 1 mm thick resolving or running gel of 8% of pH 8.8 was prepared and

a 5% stacking gel (pH 6.8) was casted over the running gel. The haemolymph protein samples were mixed with sample buffer (50 mM Tris-HCl, pH 6.8, 2% SDS, 10% glycerol, 0.1% bromophenol blue, 5% 2-mercaptoethanol) such that the protein concentration for each sample is 100 ug per well. The samples were boiled for 2–3 min in water maintained at 100 °C. The samples were then centrifuged at 10,000 rpm for 5 min in a refrigerated centrifuge at 4 °C and then loaded into the wells of the gel. Electrophoresis of the protein was carried out initially at 30 mA current till the sampled entered the running gel and then at 40 mA till the end of the run. The temperature of the gel was maintained at 14 °C using a circulating water bath (Haake, D 8G). Standard molecular markers (Promega M.W.-V^{5291}) were also run along with the samples each time.

The high-range protein molecular weight markers used are as follows:

S.No	Marker protein	Molecular weight	R_m on 8% gel
1	Myosin	212	0.19
2	B-Galactosidase	116	0.23
3	Phosphorylase-B	97.4	0.34
4	Bovine serum albumin	66.2	0.38
5	Catalase	57.5	0.45
6	Aldolase	40	0.68

The electrophoresed gels were fixed in 12% trichloro acetic acid for one hour and stained overnight with 0.25% Coomassie brilliant blue R-250 in methanol: acetic acid: water (40 : 10 : 50). Excess stain was removed using methanol: acetic acid: water (40 : 10 : 50) solution, changing the destaining solution 3–4 times. The destained gels were stored temporarily in water containing 20% glycerol. The relative mobility (R_m) of different protein fractions were calculated as follows:

$$R_m = \frac{\text{Distance travelled by the protein fraction}}{\text{Distance travelled by the tracking dye}}$$

The molecular weights of the different protein bands in each sample were determined from the standard curve drawn between log molecular weight and R_m values (Fig. 2).

RESULTS AND DISCUSSION

Quantitative changes in haemolymph proteins

Haemolymph protein concentration of the control larvae increased with the advancement of age from an initial value of 124.5 mg ml^{-1} (24 h) to 238.7 mg ml^{-1} at the end of the feeding period (72 h) followed by a decline at 96 h (214.48 mg ml^{-1}). The highest protein concentration was observed at 120 h (Table 1). Higher protein content at 72 h coincided with the active feeding phase. Such coincidence of higher haemolymph protein concentration with active feeding phase of final instar larvae was

TABLE 1. Effect of plant oils on haemolymph protein concentration of final instar *H. armigera*

Treatment (oils)	Haemolymph protein(mg ml^{-1}) Hours after treatment					
	24 h	48 h	72 h	96 h	120 h	Mean
Artemisia	30.05^{c} ±0.43	114.09^{b} ±5.36	131.56^{c} ±6.93	148.80^{c} ±2.88	110.19^{d} ±3.91	106.94
Ageratum	27.4^{d} ±0.26	29.01^{c} ±0.31	97.45^{d} ±2.38	128.48^{d} ±2.28	150.13^{c} ±1.51	86.49
Azadirachta	33.76^{b} ±0.28	116.69^{b} ±2.61	142.59^{b} ±3.81	171.05^{b} ±2.28	168.57^{b} ±1.80	126.53
Control	124.48^{a} ±1.76	176.35^{a} ±5.08	238.75^{a} ±5.14	214.48^{a} ±8.62	298.67^{a} ±2.14	210.55
CD ($P = 0.05$)	1.75	7.38	9.16	9.08	4.75	

$N = 10$. Means following the same alphabet(s) are not significantly different.

reported in *Spodoptera litura* (Ayyangar and Rao, 1990) and *H. armigera* (Krishnayya and Rao, 1995) as they would be synthesized *de novo* from the nutrients derived from food. Increase of haemolymph protein concentration again at 120 h may be due to re-absorption of cuticular protein during apolysis at pre-pupal stage. Such occurrence of higher protein concentration was also recorded by Krishnayya and Rao (1995) in *H. armigera*.

The protein concentration in the *Artemisia* oil treated larvae increased continuously from 24 h (30.05 mg ml^{-1}) to 96 h (148.8 mg ml^{-1}). At 96 h, there was increase in protein concentration in the treated insects as against its decrease in control larvae. However, at 120 h reverse trend was observed. There was a marginal increase in the protein concentration of the *Ageratum* oil; treated larvae from 24 h (27.4 mg ml^{-1}) to 48 h (29.01 mg ml^{-1}). However, substantial increase was noticed at 72 h which continued till 120 h. The inhibitory effect of *Ageratum* oil on haemolymph protein concentration of the last instar of *H. armigera* is evidenced by the overall mean protein concentration in the treated larvae (86.5 mg ml^{-1}) which was significantly lower than control larvae (210.5 mg ml^{-1}). The overall trend in the protein concentration of *Azadirachta* oil treated larvae was similar to that of *Artemisia* oil treated ones. There was a drastic reduction in the haemolymph protein concentration of *A. indica* oil treated larvae. In all the three treatments, conspicuously lower protein concentration compared to control larvae may be attributed to reduced feeding activity.

The haemolymph protein profiles of control and treated larvae are presented in Table 2 and Plate 1. the molecular weights of proteins were determined by the regression equation obtained from standard high molecular weight proteins. The staining intensity of protein bands increased from early stage onwards to the last

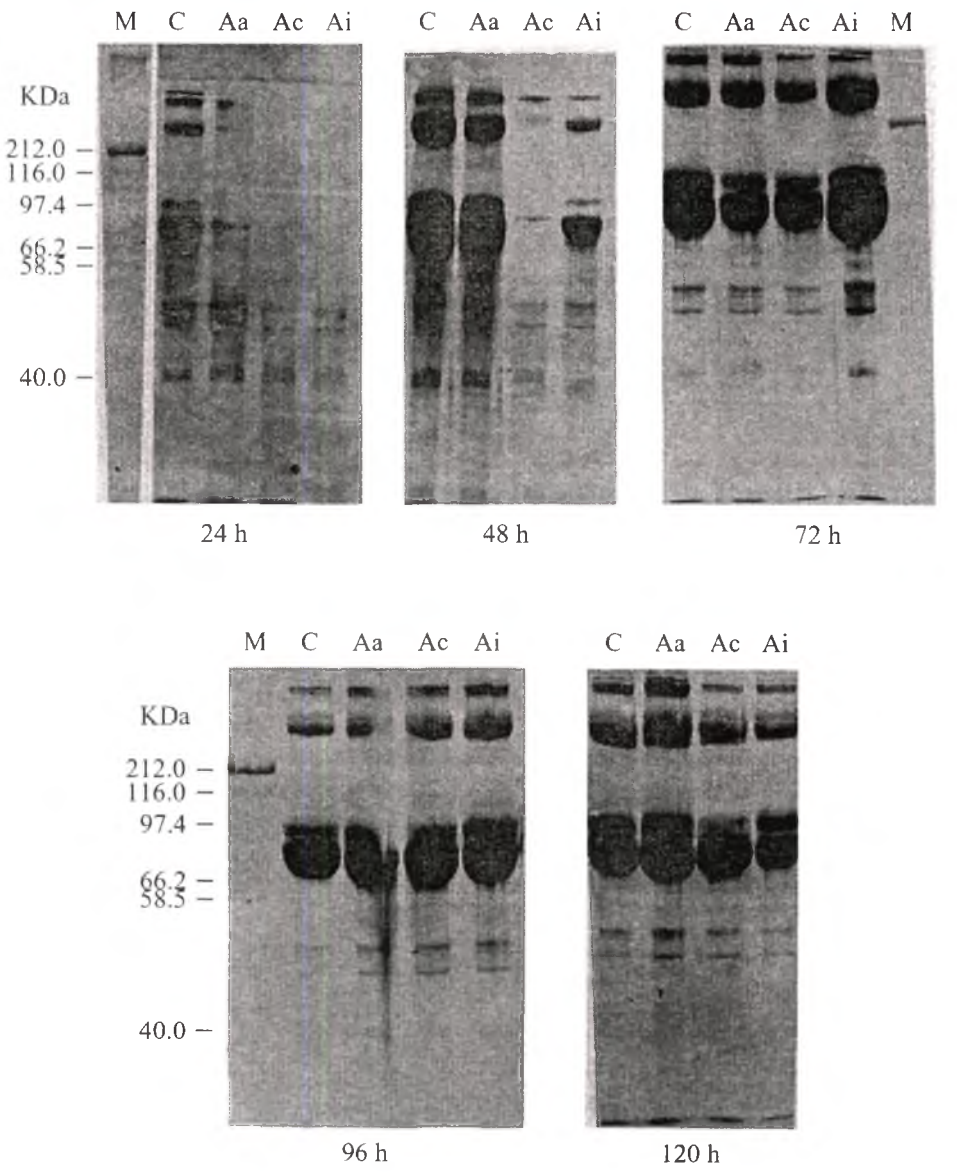

Plate1: Electrophoretic profile of haemolymph proteins of final instar *Helicoverpa armigera* (SDS-PAGE, 8%)

Samples from 24,48,72,96 and 120 h old larvae

Lanes M:Marker
C: Control

Treatments Aa:*Artemisia annua* oil
Ac:*Ageratum conyzoides* oil
Ai:*Azadirachta indica* oil

TABLE 2. Haemolymph protein profile of final instar *H. armigera*

Molecular weight (kDa)	Hours after treatment																			
	24 h				48 h				72 h				96 h				120 h			
	C	Aa	Ac	Ai	C	Aa	Ac	Ai	C	Aa	Ac	Ai	C	Aa	Ac	Ai	C	Aa	Ac	Ai
253.5	+	+	−	−	+	+	−	−	+	−	−	+	+	+	−	+	+	+	−	+
235.0	+	+	−	−	+	+	+	+	+	+	+	+	+	+	+	+				
185.8	+	−	−	−	++	++	−	+	++	+	+	+	+	+	+	+	+	+	+	+
106.2	+	−	−	−	+	+	−	+	+	+	+	+	+	+	+	+	+	+	+	+
84.1	++	−	−	−	++	++	+	++	+++	++	++	++	++	++	++	++	++	++	++	++
58.9	−	−	−	−	+	+	−	−	+	−	−	−	−	−	−	−	+	+	+	−
50.5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
43.2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
28.7	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	+	+	−	−
26.6	−	−	−	−	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−
23.4	−	−	−	−	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−

+, ++, + + + refer to the increased intensity of staining; − refers to not stained.
C = Control; Aa = *Artemisia annua*; Ac = *Ageratum conyzoides*; Ai = *Azadirachta indica*.

day of the instar, indicating an increase in protein concentration. Based on the intensity of staining (>0.25 AU) a total of 11 bands was recorded. The protein band of molecular weight 84.1 kDa was most intensely stained and was observed in all stages of development in control insects. A remarkable increase was seen in the concentration of this protein (84.1 kDa) as the development of the insect progressed. This may be designated as storage protein because of its greater intensity of staining characterized by higher aromatic amino acid content. Haunerland and Bowers (1986) reported a similar protein of molecular weight 76 kDa as arylphorin in *H. zea* as determined by non-denaturing, pore-limiting PAGE. The other proteins of prominence in control insects were of 235, 85.8 and 106.2 kDa molecular weights.

Eight proteins 235.5, 235.0, 185.8, 106.2, 84.1, 50.5, 43.2, 28.7 kDA) were observed in the haemolymph of control insects during active feeding phase (24 h). However, in *Artemisia* oil treated insects only 5 proteins (235.5, 235.0, 50.5, 43.2 and 28.7 kDa) were stained appreciably. Whereas, in *Ageratum* and *Azadirachta* oil treated larvae only three proteins (50.5, 43.2 and 28.7 kDa) were observed during the active feeding phase. In both these treatments, none of the high molecular weight proteins including the storage protein were stained. Intensely stained high molecular weight proteins of 253.5 and 235.0 kDa were however observed in *Artemisia* oil treated insects. This difference in number of proteins between control and treated insects may be attributed to treatmental effect coupled with lack or reduced feeding.

Later at active feeding (48 h) 11 proteins were observed in both control and *Artemisia* oil treated insects. Whereas *Ageratum* and *Azadirachta* oils treated insects have recorded only 7 bands. The recovery of *Artemisia* oil treated insects after the treatment was mainly due to the maintenance of internal equilibrium (homeostasis) which was pronounced in *Ageratum* and *Azadirachta* oils treated insects at later stages. There was no marked difference in the protein profiles in control and treated insects at early and late pre-pupal phase may be due to recovery of the treated insects. The greater intensity of storage protein observed at 72 h coincides with the commitment peak of 20-hydroxyecdysone (Dean *et al.*, 1985) which decreased at early and late pre-pupal stages mainly because of sequestration of this storage protein by fat body. The absence or late appearance of some proteins in treated insects suggest the interference of the oils with protein synthesis.

ACKNOWLEDGMENTS

The senior authority is sincerely thankful to the Director, Indian Agricultural Research Institute, New Delhi, for providing IARI Senior Fellowship during the tenure of her Ph.D. programme.

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(Received in June 1999; revised and accepted in April 2000)

ENTOMON 25(2): 117–128 (2000)
Article No. ent.25207

Pteromalidae (Chalcidoidea : Hymenoptera) from India with The Description of a New Species

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ABSTRACT: Eight species of Pteromalidae under the genera *Homoporus* and *Pachyneuron* from India are dealt with. *Homoporus gladiatus* sp. nov. is described. Key to the Indian species of *Pachyneuron* is revised.

KEYWORDS: *Homoporus*, *Pachyneuron*, Pteromalidae, New species, New reports.

INTRODUCTION

The present study is based on a collection of Pteromalidae from different parts of India. Eight species belonging to 2 genera, *viz.*, *Homoporus* Thomson and *Pachyneuron* Walker are dealt with. The genus *Homoporus* is reported for the first time from India and a new species, *Homoporus gladiatus* is described. The species *Pachyneuron solitarium* (Hartig) is reported for the first time from the Oriental Region. A revised key to separate the Indian species of *Pachyneuron* is provided.

Morphological terminology follows Boucek (1988). The following abbreviations are used in the text: USNM - United States National Museum of Natural History; Fl–F6 - funicular segments one to six; OOL-oculo-ocellar length; POL - postero-ocellar length; SMV - submarginal vein; MV - marginal vein, PMV - postmarginal vein; STV - stigmal vein.

The specimens of the present study are housed in the collections of Zoological Survey of India, Calicut.

Pachyneuron Walker

Pachyneuron Walker, 1833: *Ent. Mag.* 1 : 371. Type species *Pachyneuron formosum* Walker, by monotypy.

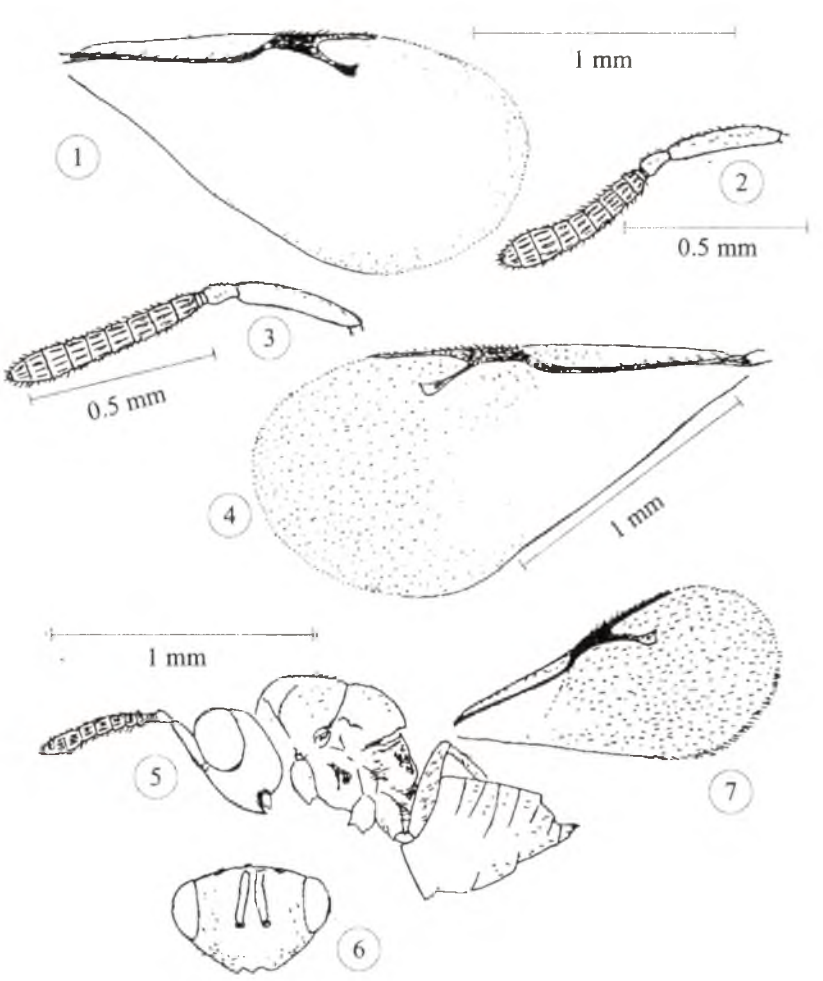
Serinus Brethes, 1913: *Ann. Mus. Nac. Hist. Buenos Aires*, 24 : 90. Type species *Serinus argentinus* Brethes, by monotypy.

Atrichoptilus Delucchi, 1955. *Z. Angew. Ent.* 38 : 141. Type species *Pachyneuron aeneum* Masi, by original designation.

Boucek (1988) provided the other synonyms under the genus and Boucek and Heydon (1997) treated *Neopachyneuron* Girault as a subgenus of *Pachyneuron*. The genus is cosmopolitan with 15–20 species (Boucek, 1988). In India the genus is represented by 6 species. Boucek *et al.* (1979) and Subba and Hayat (1986) provided the synonymy, distribution and biology of Indian species. Mani (1989) provided a key to the Indian species of *Pachyneuron* and the descriptions of Indian species based on his specimens. One of us (PMS) examined the holotypes of Indian species of *Pachyneuron* deposited by Mani in USNM and further fresh material from different parts of the country. Based on the observations of the material, a revised key to the Indian species is provided. Diagnostic characters and data on distribution and biology are provided under each species.

Key to the Indian species of *Pachyneuron* Walker. (Modified from Mani (1989))

1. Antenna with 3 anelli and 5 funicular segments (Fig. 5); forewing with MV thick, about 2.7x as long as its maximum width (Fig. 7); anterior margin of clypeus strongly produced and rounded at middle (Fig. 6) ..... *aphidis* (Bouche)
   Antenna with 2 anelli and 6 funicular segments; forewing with MV less thick, more than 4x as long as its maximum width (if thicker, then without apical fringe and PMV only slightly longer than STV); medially produced portion of clypeus having its anterior margin emarginate or truncate 2
2. Forewing with speculum closed below; propodeum narrowed posteriorly and remarkably produced beyond bases of hind coxae (Fig. 14), median area of it longitudinally and broadly elevated and plicae indicated by an elevation between basal fovea and spiracular sulcus so that a 'V' shaped depression is formed between the median and lateral elevations; petiole slender ... *solitarium* (Hartig)
   Forewing without speculam (if speculum closed, then then MV little longer than STV and petiole not slender); propodeum not much produced beyond bases of hind coxae, median area without any depression as above 3
3. Forewing with apical fringe 4
   Forewing without apical fringe (Figs 1, 4) 6
4. Forewing with MV shorter than STV (Fig. 17) ..... *leucopiscida* Mani
   Forewing with MV longer than STV 5
5. Scutellum with a faint frenum (Fig. 10); forewing with discal ciliation less dense than in alternate (Fig. 9), basal part bare, marginal and cubital folds and speculum absent; MV 4.3x as long as wide ..... *groenlandicum* (Holmgren)
   Scutellum without frenum; forewing with dense discal ciliation (Fig. 15) with hairy basal and cubital folds and closed speculum; MV 4x as wide as long *chambaense* Mani & Saraswat
6. Antenna (Fig. 2) with all funicular segments thicker than long; forewing with MV about 2x as long as wide; PMV only little longer than STV (Fig. 1) ... *aeneum* Masi
   Antenna (Fig. 3) with funicular segments longer than thick except last two little



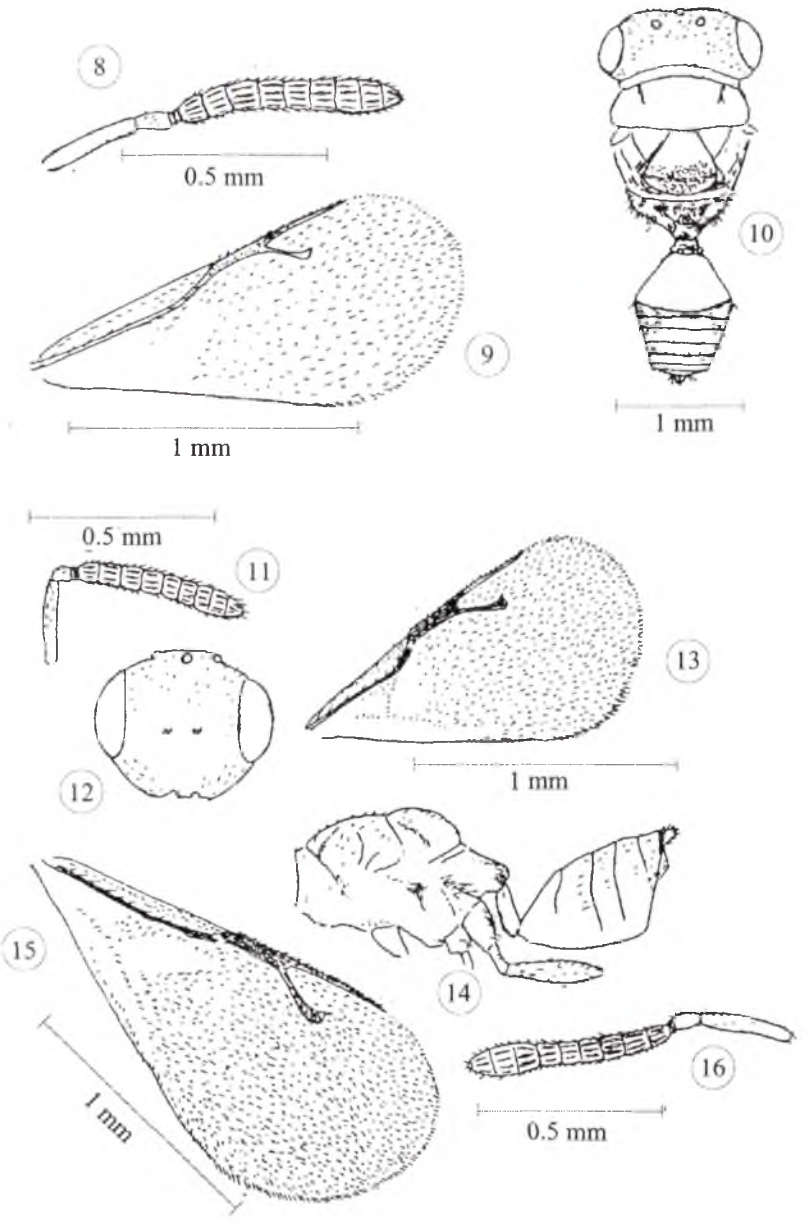
FIGURES. 1–7. Fig. 1–2 *Pachyneuron aeneum* Masi, Female 1. Forewing. 2. Antenna; 3–4 *Pachyneuron ahlaense* Mani & Saraswat, Female. 3. Antenna. 4. Forewing; 5–7 *Pachyneuron aphidis* (Bouche'), Female. 5. Body in profile, 6. Head in front view. 7. Forewing.

wider than long; forewing (Fig. 4) with MV about 3.5x as long as wide; PMV much longer than STV ..... *ahlaense* Mani & Saraswat

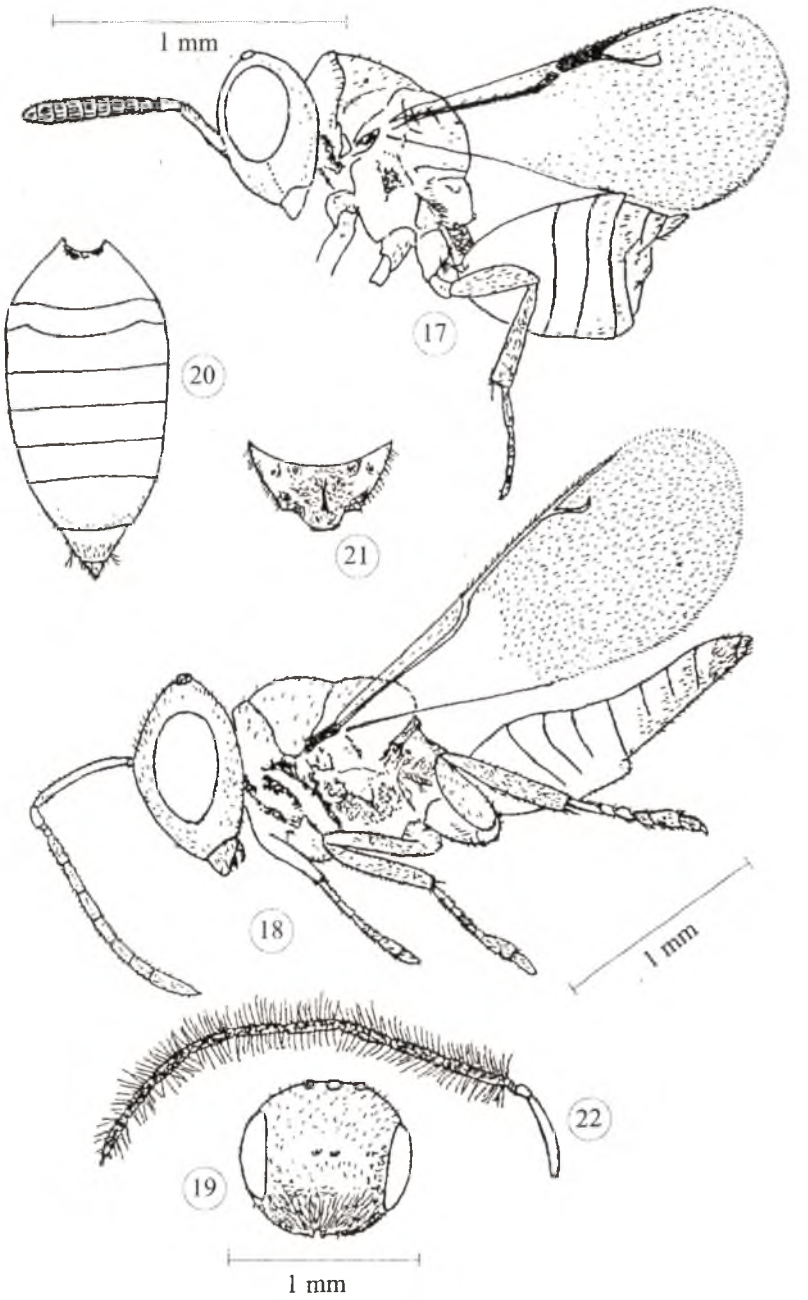
Pachyneuron aeneum Masi (Figs 1 & 2)

Pachyneuron aeneum Masi, 1929. *Ann. Mus. Civ. Stor. Nat. Giacomo Doria* 53: 229.

Pachyneuron kamathi Mani & Saraswat, 1974. *Mem. School Ent. Agra* No. 3:93



FIGURES. 8–16. Fig. 8–10 *Pachyneuron groenlandicum* (Holmgren), Female. 8. Antenna. 9. Forewing. 10. Body in dorsal view; 11–14 *Pachyneuron solitarium* (Hartig), Female. 11. Antenna. 12. Head in front view. 13. Forewing. 14. Body in profile; 15–16 *Pachyneuron chambaense* Mani & Saraswat, Female. 15. Forewing. 16. Antenna.



FIGURES. 17–22. Fig. 17 *Pachyneuron leucopiscida* Mani, Female. Body in Profile; 18–22 *Homoporus gladiatus* sp. nov., Female. 18. Body in profile. 19. Head in front view. 20. Gaster in dorsal view. 21. Propodeum in dorsal view. 22. Male antenna.

Pachyneuron deccanensis Mani & Saraswat, 1974. *Mem.School Ent. Agra* No. 3:95.

One of us (PMS) examined the holotype of *P. kamathi*, based on which the following diagnostic characters of the species are provided.

Female

Body dark brown to black; antenna dark ferruginous brown. Head finely reticulate; clypeus with anterior margin weakly emarginate. Antenna (Fig. 2) with 2 anelli, scape not reaching median ocellus; funicular segments thicker than long. Thorax finely reticulate, reticulation in the hind part of scutellum larger. Forewing (Fig. 1) without marginal fringe, discal ciliation very sparse, indistinct; PMV only slightly longer than STV; MV strongly thickened, only about 2x as long as its maximum width. Gastral petiole slightly transverse, subconical, shiny, with obscure reticulate microsculpture.

Material examined

Holotype Female of *P.kamathi* (on slide), USNM collection, India, 1–3 Dhenkund Dalhousie, 23.v.1971, Coll.M.K.Kamath.

Distribution: India (Maharashtra, U.P., Himachal pradesh), Europe, Turkey, Libya.

Host: ex.Syrphid puparia (Boucek *et al.*, 1979).

***Pachyneuron ahlaense* Mani & Saraswat (Figs 3 & 4)**

Pachyneuron ahlaensis Mani & Saraswat, 1974. *Mem. School Ent. Agra* No. 3:90.

PMS examined the holotype of *P.ahlaensis*, based on which the following diagnostic characters are provided.

Female

Body black with metallic bluish green reflections; gaster brownish black; antenna ferruginous brown. Head with prominent fine reticulate microsculpture; clypeus emargiante anteriorly. Antenna (Fig. 3) with 2 anelli; funicular segments longer than wide except the last two little wider than long. Forewing without marginal fringe; discal ciliation sparse and fine, almost bare basally (Fig. 4). Gaster with petiole wider at base, about 0.1x of gaster; gaster including petiole little more than 0.5x rest of the body.

Material examined

Holotype Female of *P.ahlaensis* (on slide) USNM collection, India. I–l, Ahla, Dalhousie, 30.v.1971, Coll. Mani & party.

Distribution: India (Delhi, Himachal pradesh, Karnataka).

Host; ex. Syrphid puparia (Boucek *et al.*, 1979)

***Pachyneuron aphidis* (Bouche') (Figs 5–7)**

Diplolepis aphidis Bouche', 1834. *Naturg. Ins. Berlin.* 5:170.

Pachyneuron lali Mani, 1939. *Indian J. ent.* 1:81.

Pachyneuron ferrieri Mani, 1939. *India J.ent.* 1:83.

Pachyneuron triarticulata Mani & Saraswat, 1974: *Mem. School Ent. Agra* No. 3:98.

PMS examined the holotype of *P.triarticulata* and specimens from USA kindly donated by Steven Heydon, based on which the following diagnostic characters are provided.

Female

Body brownish black; gaster with a greenish or bluish tinge, shiny; antennal scape brownish black, pedicel and flagellum dark brown. Anterior margin of clypeus (Fig. 6) strongly produced and rounded at middle. Antennae (Fig. 5) with 3 anelli and 5 funicular segments; third anellus nearly as long as the first and second combined. Thorax strongly arched dorsally; propodeum finely reticulate, its surface flat, without elevations or carinae. Forewing (Fig. 7) with MV thick, about 2.7x as long as its maximum width; basal cell bare, open below; speculum open below. Gaster rounded, with petiole not longer than wide, smooth.

Material examined

Holotype Female of *P. triarticulata* (on slide) USNM collection, India, l–l Ahla, Dalhousie, 27.v.1971, Coll. Mani & party; 1 Female, 1 Male, USA, CA yolo co.putach creek, S. W. Davis, 26.ii.1996, Coll.Carmean.

Distribution: India (Delhi, Haryana, Jammu & Kashmir), Pakistan, Europe, America, Japan.

Host: ex. *Myzus* sp.on *Prunus domestica*, ex. *Aphidius* sp.on *Macrosiphum*, *Aphis rumicis*, *Brachycaudus helichrysi* and indet. aphids in India (Boucek *et al.*, 1979).

***Pachyneuron groenlandicum* (Holmgren) (Figs 8–10)**

Pteromalus groenlandicus Holmgren, 1872. *Ofvers Kungl. Vet. Akad Forn.* 29:100.

Pachyneuron Karnalensis Mani, 1939. *Indian J. ent.* 1:85.

Pachyneuron umbratum, Delucchi, 1955. *Acta. Univ. Lund* (N.S.) (*Avd* 2) 50(20): 132–133.

Pachyneuron bakrotus Mani & Saraswat, 1974: *Mem. School Ent.Agr.* No. 3:102.

PMS examined the holotype of *P bakrotus* and fresh specimen from India, based on which the following diagnostic characters are provided.

Female

Body bluish black with metallic reflection; antennae dark brown; scape paler; coxae concolrous with thorax, remainder of legs brown. Clypeus slightly emarginate or truncate anteriorly. Antennae (Fig. 8) with scape reaching front ocellus. Thorax (Fig. 10) moderately reticulate. Scutellum with a faint frenum. Propodeum with nuchal area polished; median carina absent. Forewing (Fig. 9) without speculum, scattered hairs on the basal part, few hairs on the basal hair line. Gastral petiole widened towards the end, reticulate, longer than thick; gaster fusiform, short.

Material examined

Holotype Female of *P.bakrotus* (on slide) USNM collection, India, l–6 Upper Bakrota, Dalhousie, 12.v.1971, Coll.Mani. & party; 4 Females, India, Karnataka, Bangalore, ex. *Ishiodon* sp. on *Cassia* sp., 20.x.1988, Coll. Srinivas; 1 Male, Kerala, Kalkandi (Palghat), 12.xii.1987, Coll.P.M.Sureshan.

Distribution: India (Delhi, Himachal pradesh, Kerala, Haryana, Jammu & Kashmir, Orissa, Tamil Nadu, Karnataka), Europe.

Hosts: ex.*Ishiodon* sp.on *Cassia* sp., Syrphid with *Brachycaudus* sp. (Boucek *et al.*, 1979).

***Pachyneuron solitarium* (Hartig) (Figs 11–14)**

Pachyneuron coccorum auctt., ex parte (nec. *Ichneumon coccorum*) Linne., 1758.

Chrysolampus solitarius Hartig, 1838. *Jahresb Forstwiss. Forst. Naturk. l*: 250.

This forms the first record of the species from the Oriental Region. Based on the examination of the Indian specimen the following diagnostic characters of the species are provided.

Female

Head and thorax bluish black; gaster dark bluish green; scape yellowish brown; pedicel and flagellum dark brown; coxae concolrous with thorax; femora dark brown, remainder of legs yellowish brown. Median produced portion of clypeus narrow with anterior margin slightly emarginate or truncate (Fig. 12). Scape reaching upper edge of front ocellus. Mid lobe of mesoscutum coarsely reticulate. Scutellum (Fig. 14) moderately convex. Propodeum sloping at less steep angle relative to the tangential plane of mesoscutum and scutellum, narrowed posteriorly and remarkably produced beyond base of hind coxae. Propodeum densely reticulate; nucha finely reticulate with front edge not distinctly defined. Forewing with MV as long as STV; speculum closed below. Gastral petiole slender, shiny; gaster fusiform (Fig. 14).

Material examined

1 Female, India: Kerala, Kottiyam (Nr.Trivandrum), 23.ii.1989, Coll. P. M. Sureshan.

Distribution: India (Kerala), Japan, Europe.

Hosts: No host data is available from India. According to Kamijo and Takada (1973), the species has wide range of hosts, hyperparasitising aphids, coccids and eggs of *Dendrolimus* (Lepidoptera) through *Ooencyrtus,Telenomus* and *Trichogramma*.

***Pachyneuron chambaense* Mani & Saraswat (Figs 15–16)**

Pachyneuron chambaensis Mani & Saraswat, 1974. *Mem.School Ent.Agra* No. 3:100.

Pachyneuron jandrighatensis Mani & Saraswat, 1974. *Mem.School Ent. Agra* No. 3:104.

PMS examined the holotype of *P. chambaensis*, based on which the following diagnostic characters of the species are provided.

Female

Body dark brown to black with metallic blue green reflection; antennae dark brown. Head finely reticulate; clypeus anteriorly truncate. Antenna (Fig. 16) with scape long, slightly more than 5x as long as wide; club equal to 3.5 preceding segments combined. Thorax finely reticulate. Propodeum without carina. Forewing (Fig. 15) with relatively dense pubescence, with hairy basal and cubital folds and closed speculum. Gaster with petiole shiny, 1.66x as long as thick; gaster including petiole about 0.5x rest of the body.

Material examined

Holotype Female of *P. chambaensis* (on slide) USNM collection, India, 1–4 Jandrighat, Dalhousie, 19.v.1971, Coll. Mani & party.

Distribution: India (Himachal pradesh).

Host: Unknown.

***Pachyneuron leucopiscida* Mani (Fig. 17)**

Pachyneuron leucopiscida Mani, 1939. *Indian J. Ent.* 1:86.

Pachyneuron cremifaniae Delucchi, 1953. *Bull. Inst. R. Sci. Nat. Belge* 29: 8–12.

Based on the examination of several fresh specimens the following diagnostic characters of the species are provided.

Female

Body dark metallic blue; gaster brownish black, scape pale brown, remainder of antenna dark brown; legs with coxae concolrous with thorax except the middle coxae brownish; femora dark brown except for the tips and remainder of legs honey yellow. Head finely reticulate. Anterior margin of clypeus weakly emarginate. Antenna (Fig. 17) with scape just reaching front ocellus; funicular segments almost as long as thick; POL 2x OOL. Pronotum polished in the posterior half; collar finely carinate. Mesoscutum with notauli deep and incomplete. Scutellum in profile weakly convex. Propodeum with median area moderately reticulate; nucha almost smooth and marked off by a distinct constriction. Gaster fusiform; first tergite occupying nearly half length of gaster; petiole longer than hind coxa, reticulate, longer than thick.

Material examined

1 Female, India : Kerala, Anakkatty (Palghat district), 12.xii.1987; 1 Female, Kerala, Kayamkulam, 21.ii.1989; 7 Females, Kerala, Shertallai, 27.ii.1989; 2 Females, Kerala, Kottiyam (Quilon District), 23.ii.1989; 1 Female, Kerala, Calicut University Campus, iv.1987; 1 Female, Kerala, Sreekaryam, 25.ii.1989; 1 Female, Silent valley (Palghat district) 30.xii.1989; 1 Female, Kerala, Attingal (Trivandrum District), 23.ii.1989 (Coll. P. M. Sureshan).

Distribution: India (Kerala, Bihar, Tamil Nadu, Delhi), Europe.

Hosts: ex.*Leucopis nigricornis* on *Zea mays* and *Dactylopius* sp. on cotton from India (Boucek *et al.*, 1979).

***Homoporus* Thomson**

Homoporus Thomson, 1878. *Hym. Scand.* 5: 64. Type species. *Pteromalus fulvicornis* Walker, designated by Ashmead, 1904.

Phaenacra Foerster, 1878. *Verh. Naturh. ver. preuss Rheinl.* 35: 51.Type species: *Phaenacra nubigera* Foerster, by monotypy.

Parapteromalus Ashmead, 1904. *Mem. Carnegie Mus.l*: 320, 384. Type species: *Parapteromalus isosomatus* Ashmead, by monotypy and original designation.

Merisoporus Masi, 1924. *Ann. Mus. civ. stor. Nat. Genova.* 50:226. Type species *Pteromalus luniger* Nees, by original desigantion.

Pseudomerisus Erdos & Novitzky, in Erdos, 1953: *Acta Biol. Acad. Scient. Hungaricae* 4: 236. Type species. *Pseudomerisus stipae* Erdos & Novitzky, by original designation.

Homoporus Thomson is well known from the Western palaearctic and Nearctic regions. From the Oriental region the genus is very poorly known. Boucek *et al.* (1979) mentioned one undetermined species of *Homoporus* from Pakistan. Here one new species is described under the genus from India. This forms the first record of the genus form India.

***Homoporus gladiatus* sp.nov. (Figs 18–22)**

Female

Length 2.5–2.8 mm (Holotype 2.7 mm). Head and thorax black without metallic lusture; gaster pale brownish yellow with two dark brownish lines dorso-laterally on either side, tips also dark brown. Antennae except basal part of scape brown; scape basally and club fully testaceous; legs with coxae concolrous with thorax; fore and mid femora brown; hind femora, all tibiae and tarsi testaceous; tips of tarsi brown. Tegulae black; wings hyaline; veins pale brown.

Head

(Figs 18, 19): Finely reticulate; clypeus and lower face radiately striated. In dorsal view head width 1.9x length and in front view width 1.1x height; vertex behind ocelli

abruptly sloping; temple length 0.4x eye length, ocelli large; POL subequal to OOL; malar grooves indistinct, malar space length one third of eye length; clypeus anteriorly with a deep notch in the middle; scrobe represented by a concavity near the base of antenna. Antenna (Fig. 18) inserted in the middle of face; scape reaching beyond median ocellus, length almost equal to eye length; anelli subequal, first short, all funicular segments slender; club sharply pointed at tip, length 2.2x that of preceding segments combined.

Thorax

(Figs 18): Pronotum reticulate punctate, narrower than mesoscutum, lateral panel with deep oblique furrow. Mesoscutum reticulate punctate, width 1.8x length; notaular grooves reaching up to middle. Scutellum highly convex, little wider than long, similarly sculptured as on mesoscutum. Dorsellum very finely reticulate. Propodeum (Fig. 21) width 2.2x length, finely reticulate, median carina indicated towards the hind part, not complete, nucha convex, anteriorly constricted, spiracles short, oval, closer to hind margin of metanotum; plicae almost indistinct, callus densely pilose. Mesopleuron moderately reticulate except for a triangular shiny area beneath the wings. Metapleuron very finely reticulate. Prepectus short, almost smooth. Legs with last tarsal segment swollen, prominent on mid and hind legs. Forewing (Fig. 18) with basal vein bare; speculum open below; marginal fringe small. Relative lengths of SMV, MV, PMV, and STV as 29, 21, 15 and 6.

Gaster

(Figs 18 & 20): Elongate ovate, dorsally collapsing, with a very short petiole visible dorsally; gaster length 2.1x width; hind margin of first two tergites slightly produced, others straight; ovipositor sheath slightly protruding out; hypopygium reaching middle of gaster.

Male

Length 1.9–2.6mm. Closely resembles female except for the following characters. Antenna (Fig. 22) inserted high up on the face; funicle segments elongate with moderately dense erect hairs; anelli very short; gaster short; black with a yellow spot sub apically on dorsal part reching little beyond middle; hind femora black and last tarsal joints less swollen.

Holotype

Female: India: Kerala, Calicut (Thiruvannoor), iii. 1999, coll.Rajmohana; *Allotype*: Male with same data as that of holotype; *Paratypes*: 3 Females, 4 Males, data same as that of holotype; 3 Females, Kerala, Malampuzha, 13.i.1986; 1 Male, Neeleswaram, 26.ii.1988; 1 Female, 2 Males, Malampuzha, 11.xii.1987; 2 Females, Mukali (palghat), 10.xii.1987; 10 Males, Calicut University Campus, iii.1987 (Coll. P. M. Sureshan).

Remarks

This species resembles *H.destructor* Say in having pronotum in front of collar descending vertically, so that the neck is hardly visible, malar space one third as long as eye, immaculate forewing and relatively stout legs, but differs in having gaster long (length 2.1x width) not black or reddish basally (in *destructor* gaster short, 1.4–1.6x as long s wide, black with metallic reflections or sometimes reddish basally) and mandibles with three and four teeth (in *destructor* both mandibles with four teeth).

Etymology

The species name is an arbitary combination of letters.

ACKNOWLEDGEMENTS

The first author (PMS) is grateful to the Director, Zoological Survey of India, Calcutta and the Officer-in-charge, Zoological Survey of India, Calicut for providing facilities and encouragement. We are grateful to Dr. E. E. Grissell, USNM, Washington for kindly arranging the loan of various types for the study and to Dr. Steven Heydon, Bohart Museum, California for kindly providing some speciment for the study.

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(Received in July 1999; revised and accepted in April 2000)

ENTOMON 25(2): 129–140 (2000)
Article No. ent.25208

Further Contribution to the Taxonomy and Distribution of the Genus *Lethe* Hübner (Satyridae : Lepidoptera) from North-Western Himalaya

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ABSTRACT: Six species *viz.*, *Lethe baladeva* (Moore), *L. verma* (Kollar), *L. confusa* Aurivillius, *L. insana* (Kollar), *L. rohria* (Fabricius) and *L. europa* (Fabricius) collected from various localities in the North-West Himalaya have been dealtwith in the present communication. The distribution of these species has been recorded to show their prevalence in the existing environment. Their population variations and conspecificity aspects have also been authenticated on the basis of genitalic studies.

INTRODUCTION

During the course of recent surveys, authors have collected sixteen satyrid genera from various localities in North-West Himalaya. The presently dealtwith genus, *Lethe* Hübner ranges throughout the Oriental and eastern Palaearctic regions and nearly all the species are jungle species, many of which are only found in the mountains (Pinratana, 1988). On the basis of diagnosis of the genus furnished by Evans (1932), Talbot (1947) and de Lesse (1956), six species *viz.*, *baladeva* (Moore), *verma* (Kollar), *confusa* Aurivillius, *insana* (Kollar), *rohria* (Fabricius) and *europa* (Fabricius) have been identified under this genus. The male genitalia of all and the female genitalia of the former five species have been examined with a view to assess their taxonomic significance. These structures alongwith some other morphological characters have been successfully used for interspecific descrimination of the species, mentioned above. The diagnosis of these species stands updated through present studies on their genitalia, besides distribution.

OBSERVATIONS

Genus *Lethe* Hübner
Common name: The Treebrowns

Hübner, [1819], Verz. beknnt. Schmett. 4: 56. Type-series by monotypy: *Papilio europa* Fabricius, 1775, Syst. Ent.:500; de Lesse, 1956, Ann. Soc. ent. Fr.125:80.

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Tanaoptera Billberg, 1820, Enum. Ins. Mus. Billb: 79.
Enope Moore, 1857, in Horsfield & Moore, Cat. Lep. Ins. E. India Co.1:228.
Blanaida Kirby, 1871, Syn. Cat. diurn. Lep.: 699, 42.
Charma Doherty, 1886, J. asiat. Soc. Bengal, Pt.II, 63 (1);48.
Putlia Moore, [1892], Lep.ind. 1(12): 287.
Hermias Fruhstorfer, [1911], in Seitz, Grosschmstt. Erde.9:324.

Type-species: *Papilio europa* Fabricius

Fabricius, 1775, Syst. Ent: 500.

Key to the species of the genus *Lethe* Hübner

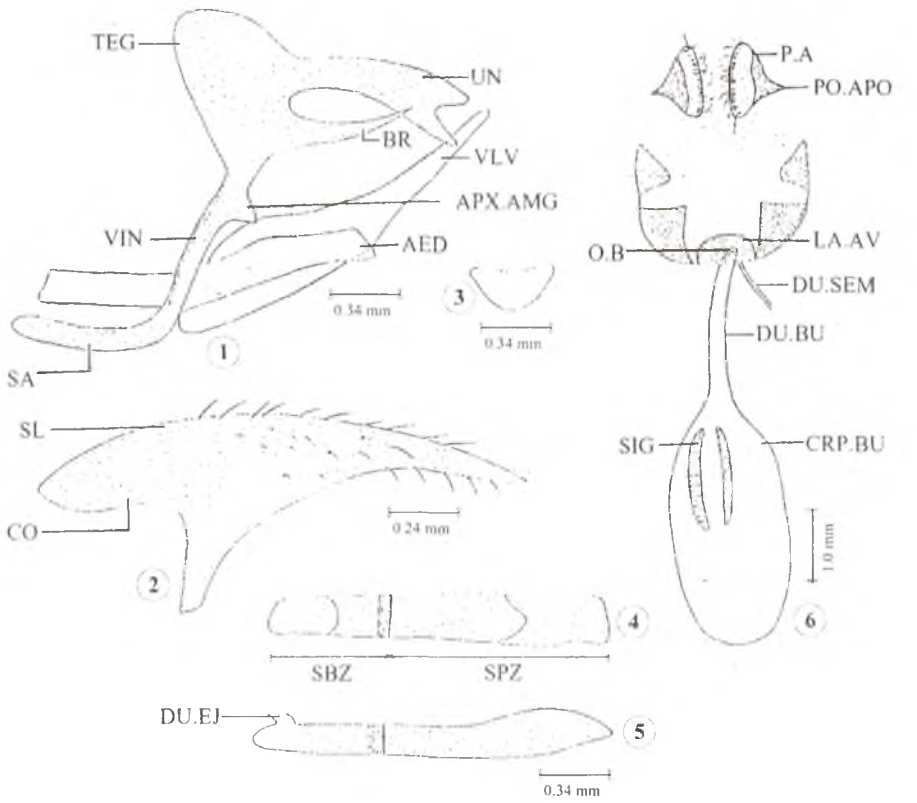
1. Antennal club spatulate; male genitalia with uncus bifid ..... *baladeva* (Moore)
   Antennal club slender; male genitalia with uncus not bifid(simple) 2
2. Forewing upperside with white band in both sexes; male genitalia with brachia bifid 3
   Forewing upperside without white band in male, white band distinct in female; male genitalia with brachia either absent or not bifid 4
3. Forewing upperside without subapical white spots; male genitalia with minute spines present on forked brachia; female genitalia with lodix rectangular in shape ..... *verma*(Kollar)
   Forewing upperside with two subapical, obliquely placed, irregular white spots; male genitalia without minute spines on forked brachia; female genitalia with lodix nearly oval in shape ..... *confusa* Aurivillius
4. Forewing upperside with one subapical, minute, white spot; hindwing underside ocelli without disintegrated centres; male genitalia with brachia more or less broadly slender, appendices angulares crescent shaped ..... *insana*(Kollar)
   Forewing upperside with two subapical, white spots; hindwing underside ocelli with disintegrated centres; male genitalia with brachia either very slender or absent, appendices angulares long, spine-like or blunt at distal end 5
5. Forewing upperside with a bifid white spot nearly in middle of costal margin present in male; hindwing underside with discal, white sinuous line, centres of ocelli in spaces M1, M2 and M3 disintegrated; male genitalia with brachia very slender, tegumen narrow, appendices angulares spine-like ..... *rohria*(Fabricius)
   Forewing upperside with white spot on costal margin wanting in male; hindwing underside without discal line, all ocelli on underside hindwing with disintegrated centres; male genitalia with brachia missing, tegumen nodule-like, appendices angulares blunt and slightly incurved distally ..... *europa*(Fabricius)

Lethe baladeva (Moore)
Common name: The Treble Silverstripe

Moore, 1865, Proc. Zool. Soc. Lond.: 769 (*Zophoessa*)

Lethe baladeva aisa Fruhstorfer

Fruhstorfer, 1911, Fauna Indo-Austral.9: 314 (*Lethe*).



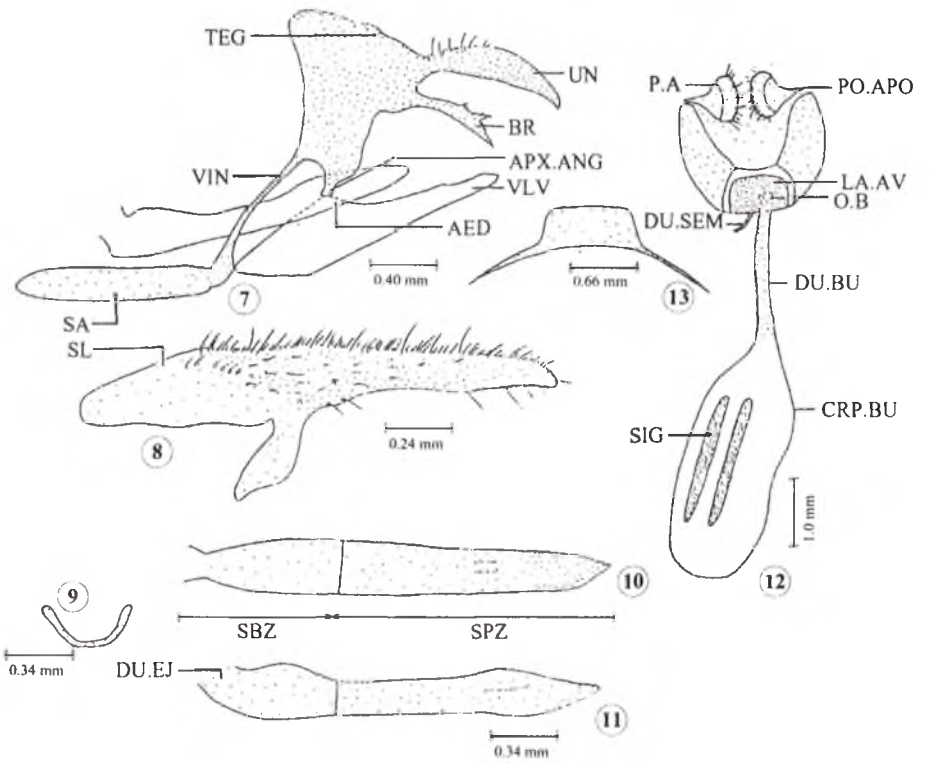
FIGURES. 1–6. *Lethe baladeva aisa* Fruhstorfer: 1 Male genitalia (lateral view); 2. Valva (inner view); 3. Juxta; 4. Aedeagus (dorsal view); 5. Aedeagus (lateral view); 6. Female genitalia (ventral view).

Male genitalia

(Figs 1–5): Uncus longer than tegumen, bifid distally, narrow at base, broader posteriorly; brachia nearly two third the length of uncus, upturned, slender; tegumen globular, narrow ventrally; appendices angulares tooth-like; vinculum longer than tegumen, uniformly broad; saccus moderately long with rounded distal end; valva with proximal half broader, distal half acuminate, pilose, costa with costal process well developed, sacculus long; juxta oval; aedeagus moderately long, posterior end weakly curved dorsally, suprazone longer than subzone, ductus ejaculatorius entering dorsad.

Female genitalia

(Fig. 6): Corpus bursae ellipsoidal membranous; signa moderately long, represented by scobinate patches, lying longitudinally in the posterior half of corpus bursae; ductus



FIGURES. 7–13. *L. verma verma* (Kollar): 7. Male genitalia (lateral view); 8. Valva (inner view); 9. Juxta; 10. Aedeagus (dorsal view); 11. Male genitalia (lateral view) 12. Female genitalia (ventral view) 13. Lodix.

bursae moderately long, membranous, broarder anteriorly, narrower posteriorly; ductus seminalis attaching ductus bursae near ostium bursae; lamella antevaginalis with central process semicircular, lareral lobes somewhat triangular, one small triangle-like lobe also fused with each lateral lobe, lamella postvaginalis missing; apophyses anteriorios wanting; apophyses posterioris small, spine-like, strongly sclerotized; papilla analis subovbate, pilose.

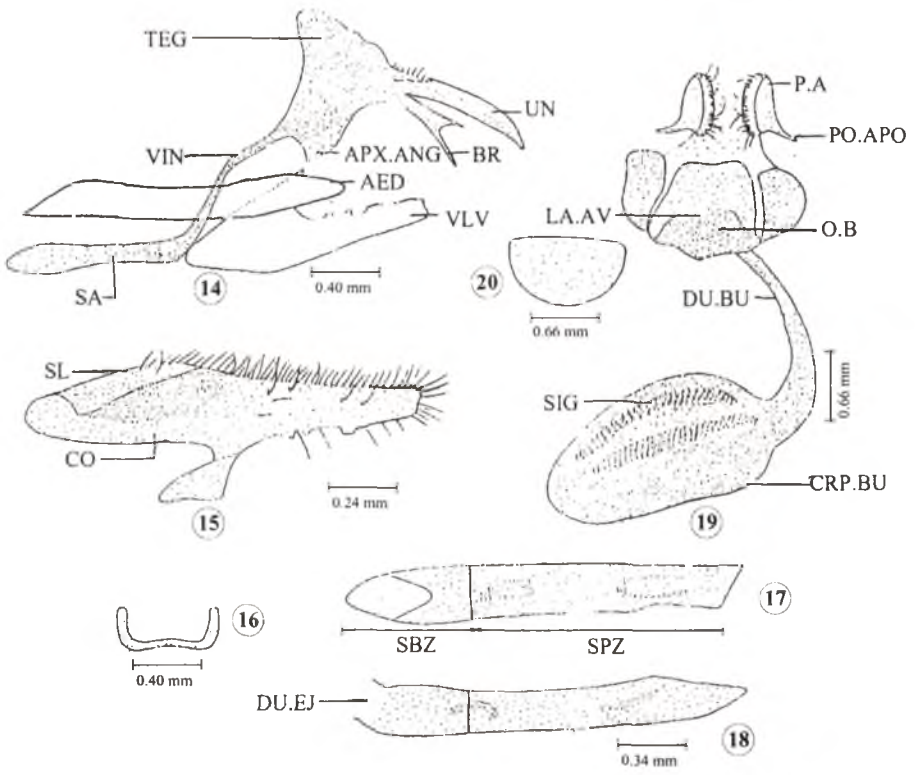
Length of forewing: Male: 28.0 mm Female: 28.0 mm

Material examined

Uttar Pradesh: 1♂, 1♀, 14.vi.94, Sonprayag, 850m, Chamoli.

Remarks

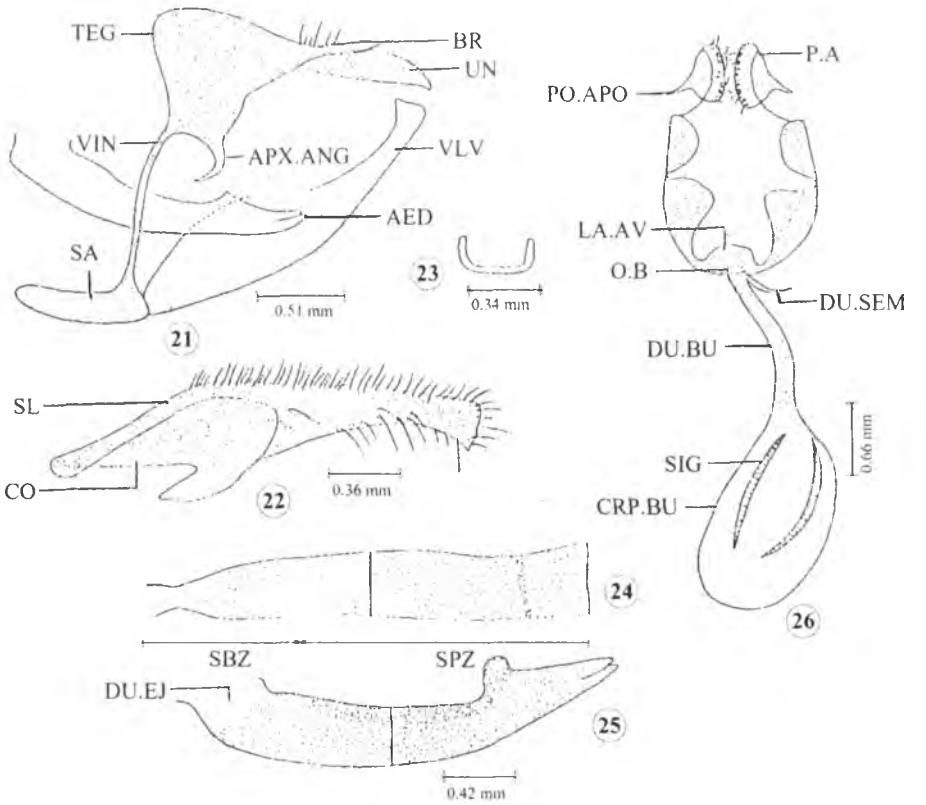
Lethe baladeva was reported as a new species from North-East Bengal (Sikkim) by Moore (1865). This zoogeographical population represents the nominotype, whereas,



FIGURES. 14–20. *L. confusa confusa* Aurivillius: 14. Male genitalia (lateral view); 15. Valva (inner view); 16. Juxta; 17. Aedeagus (dorsal view); 18. Aedeagus (lateral view); 19. Female genitalia (ventral view); 20. Lodix.

the one reported from Kumaon (Hannyngton, 1910) and Garhwal Himalaya (Mackinnon and de Niceville, 1897) represents the subspecies *aisa* Fruhstorfer (Evans, 1932; Talbot, 1947). Accordingly, the present lone male and female specimens collected from the Garhwal Himalaya are described as *Lethe baladeva aisa* Fruhstorfer. The inclusion of this species in the Wildlife (Protection) Act, 1972 is supported by the present survey work., which also calls for adopting appropriate measures for its conservation.

The species, under reference, is unique owing to characters such as bifid uncus and spatulate antennal club and is the type-species of a suppressed generic name, *Charma* Doherty. de Lesse (1956) included such species i.e., *baladeva* Moore, *luteofasciata* Pouj., *samadeva* Niceville, *albolineata* Pouj., *margaritae* Elwes and *andersoni* Atkins under *baladeva*-group. However, *argentata* Leech figured by de Lesse (1956) shows that the uncus in undivided and it appears to be an apparently wrong entry in the *baladeva* group.



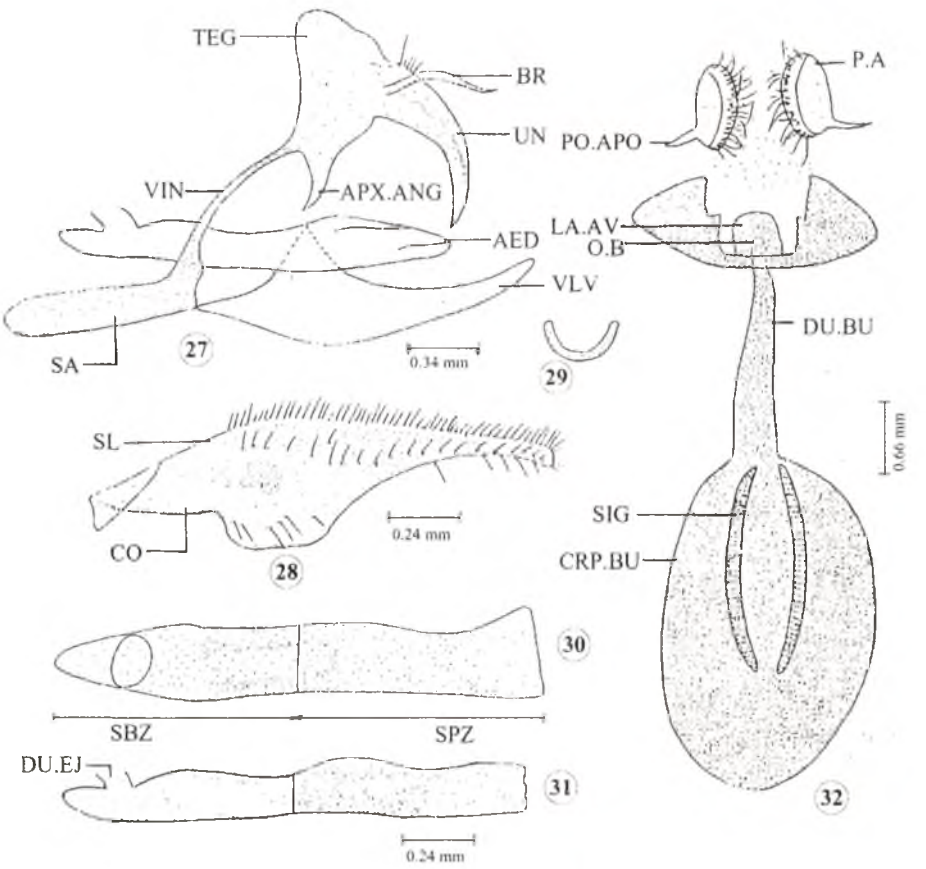
FIGURES. 21–26. *L. insana insana* (Kollar): 21. Male genitalia (lateral view); 22. Valva (inner view); 23. Juxta; 24. Aedeagus (dorsal view); 25. Aedeagus (lateral view); 26. Female genitalia (ventral view).

Lethe verma(Kollar)
Common name: The Straight-Banded Treebrown

Kollar, 1844, in Hugel's Kashmir 4: 447(*Satyrus*).

Male genitalia

(Figs 7–11) Uncus broad at middle, narrow at base, distal end pointed sparsely setosed at base with minute setae dorsally; brachia long, forked into dorsal small and central long spines, the former beset with a minute spine and latter with three minute spines, two minute spines also present before bifurcation; tegumen long and broad, grooved in the middle dorsally, narrow centrally; appendices angulares stumpy; vinculum narrow except near saccus, almost equal to tegumen; saccus long, tubular, distal end rounded; valva narrow, elongated, pilose, costa with hood-like costal process, sacculus not properly demarcated, distal half knife-like with dorsal margin crenulate; juxta U-



FIGURES. 27–32. *L. rohria rohria* (Fabricius): 27. Male genitalia (lateral view); 28. Valva (inner view); 29. Juxta; 30. Aedeagus (dorsal view); 31. Aedeagus (lateral view); 32. Female genitalia (ventral view).

shaped; aedeagus moderately long, broad at both ends, narrow at middle, distal end conical in dorsal view, ductus ejaculatorius enters dorso-anteriorly.

Female genitalia

(Figs 12–13) Corpus bursae ellipsoidal, slightly squeezed in the middle, membranous; signa comprising by two long, parallel, scobinate patches, the latter lying at equal distance from both the ends; ductus bursae smaller than corpus bursae, moderately sclerotized; ductus seminalis originate from ductus bursae near ostium bursae; central process of lamella antevaginalis squarish plate-like, lateral lobes cone-like; lamella postvaginalis wanting; lodix rectangular plate-like, the two sides produced into ray-like structures; apophyses anterioris wanting; apophyses posterioris short, pointed apically; papilla analis guttiform, pilose.

Material examined

Himachal Pradesh: 1♂, 14.vi.92, Mahog, 2150m, Chail, Shimla; 1♂, 18.ix.91, 2206m, Shimla; 1♀, 12.ix.92, Nogli, 1180m, Rampur, Shimla; 1♀, 3.vii.93, Dal Lake, 1850m, Mcleodganj, Dharmsala, Kangra; 2♀♀, 28.vi.92, Church, 1768m, Mcleodganj, Dharmsala, Kangra; 1♂, 4.vii.93, Mcleodganj-Triund, 2827m, Dharmsala, Kangra; 1♂, 22.viii.92, Dharmpur, 850m, Sarkaghat, Mandi.

Uttar Pradesh: 2♂♂, 3.vi.92, 3♂♂, 5.vi.92, 5♂♂, 1♀, 2.vi.93, 4♂♂, 3.vi.93, 1♂, 6.vi.93, 4♀♀, 11.vi.94, 1♀, 13.vi.94, 2♀♀, 2.vi.96, Bhilaru Pumping Station, 1710m, Mussoorie, Dehradun; 2♂♂, 2♀♀, 6.vi.93, Murray Electric Pumping Station, 1720m, Mussoorie, Dehradun; 2♀♀, 5.vi.93, Kemptyfall, 1645m, Mussoorie, Dehradun; 1♀, 15.vi.94, Chakrata, 2135m, Dehradun.

Jammu and Kashmir: 1♀, Kud, 1700m, Patni Top.

Remarks

The nominotype is quite common in the Western Himalaya. Unlike other *Lethe* species but like *confusa* Aurivillius, the species, under reference, has a white band on dorsal side of both the wings in either sexes. There is, in fact, no sexual dimorphism in this species. Because of the bifid brachia, Fruhstorfer (1929) proposed the genus *Hermias* Fruhstorfer for this type-series. However, the critical examination of other morphological characters shows that it conforms to the characterization of the genus *Lethe* Hübner. Somehow or the other, de Lesse (1956) included this species in *satyrina* group but did not include the generic name *Hermias* in the synonymic list of genera mentioned under *Lethe*. In view of the species broadly agreeing with the diagnosis of the genus *Lethe, Hermias*, is accordingly, included under the synonymy of the former generic name.

Lethe confusa Aurivillius
Common name: The Banded Treebrown

Aurivillius, 1898, Ent. Tidskr 18: 142 (*Lethe*)

Lethe confusa confusa Aurivillius

Male genitalia

(Figs 14–18) Uncus simple more or less straight except at distal end, longer than tegumen, beset with setae at base dorsally; brachia long, bifurcated into small dorsal and long ventral spines; tegumen broad, hump-shaped, dorsal surface produced into ridges, inwardly curved anteriorly; appendices angulares triangular; vinculum longer than tegumen, thin strap-like, slightly inwardly curved; saccus long, tubular, broad and with rounded margin distally; valva elongated, pilose, costa and sacculus not demarcated, costa with trapezoid process, distal half digitate, dorsal surface carrying unequal sized teeth, distal end slightly grooved; juxta U-shaped, sclerotized; aedeagus pencil-like in lateral view, suprazone longer, coecum with conical margin, ductus entering dorsad.

Female genitalia

(Figs 19–20) Corpus bursae elongated, strongly sclerotized; signa long, extending the whole length of corpus bursae except anterior end, furnished with minute teeth; ductus bursae longer than corpus bursae, broader anteriorly, narrower posteriorly, slightly curved; lodix simicircular plate-like; lamella antevaginalis with trapezoidal flap, lateral lobes elongated, a large flap-like structure, slightly notched posteriorly, lies below central process; lamella postvaginalis membranous; apophyses anterioris missing, apophyses posterioris short, narrow, strongly sclerotized; papilla analis elliptical, pilose.

Length of forewing, half: Male: 28.0 mm. Female: 28.0 mm.

Material examined

Uttar Pradesh: 1♂, 3.vi.93, 1♀, 5.vi.93, Bhilaru Pumping Station, 1710m, Mussoorie, Dehradun; 1♀, 6.vi.93, Murray Pumping Station, 1720m, Mussoorie, Dehradun; 1♀, 5.vi.93, Kemptyfall, 1645m, Mussoorie, Dehradun.

Haryana: 2♂♂, 27.x.96, Morni Hills, 1130m, Ambala.

Remarks

According to Mani (1986), nominotype of the species is distributed in the whole Himalaya. However, the present survey shows that it is mainly available at Mussoorie from where it has early been recorded by Ollenbach (1929), Peile (1937) and Shull (1957). Two male specimens collected from the Morni Hills in the Shiwaliks is a new record for this species. As mentioned under the remarks of *Lethe verma verma* (Kollar), this species also shows no sexual dimorphism. Amongst all the species, presently studied, it goes nearer to *verma* Kollar (type-species of *Hermias* Fruhstorfer) in respect of characters such as the brachia, shape of the tegumen, valvae and the aedeagus in the male genitalia.

Lethe insana(Kollar)
Common name: The Common Forester

Kollar, 1844, in Hugel's Kashmir, 4:448(*Satyrus*).

Lethe insana insana(Kollar)

Male genitalia

(Figs 21–25) Uncus laterally flattened, distal end pointed and slightly curved ventrally, small setae occur at proximal end dorsally; brachia half of the length of uncus, upwardly turned, slender, rather somewhat broader at base, conical at distal end; tegumen long and broad, hood-like dorsally, smaller than uncus, strongly sclerotized, narrow ventrally; appendices angulares crescent shaped, broad at base; vinculum longer than uncus, uniform in diameter; saccus small, foot-like with rounded distal end; valva elongated, proximal half broad, distal half narrow, costa with leaf-like costal process, ventro-distal half almost straight, dorso-distal half inwardly curved, produced

into small spine at distal end; juxta U-shaped; aedeagus moderately long, broad, distal end upwardly lifted, subzone smaller, ductus ejaculatorius entering dorso-anteriorly.

Female genitalia

(Fig. 26) Corpus bursae globular, membranous; signa long, quite apart, situated longitudinally, beset with minute teeth, extending from the caudal end to two-third of corpus bursae; ductus bursae almost equal in length to corpus bursae, weakly sclerotized; ductus seminalis attaching ductus bursae near ostium bursae; lamella antevaginalis with somewhat squarish central process, lateral lobes roughly triangular, two oval lobes also fused with lateral lobes posteriorly; lamella postvaginalis wanting; apophyses anterioris missing, apophyses posterioris short, membranous, narrow, papilla analis elliptical, beset with macro and micro setae.

Length of forewing, Half: Male: 28.0 mm; Female: 27.0–28.0 mm.

Material examined

Uttar Pradesh: 3♂♂, 5.vi.92, 1♂, 1♀, 3.vi.93. 1♂. 5.vi.93, 3♀♀, 11.vi.94, Bhilaru Pumping Station, 1710m, Mussoorie Dehradun, 1♂, 26.iv.92., China Peak, 1980m, Nainital.

Remarks

Though the species, under reference, has earlier been reported from Kashmir, Kangra, Shimla, Mussoorie, Kumaon, Chamba and Kullu etc. but during the course of present surveys it could only be collected from Mussoorie and Nainital. As per Peile (1937), the males are not uncommon at Mussoorie and the female is very scarce but in the present random sampling both the sexes appear to be in average numbers. Nainital in the Kumaon Himalaya is a new distributional record for this species.

Lethe rohria(Fabricius)
Common name: The Common Treebrown

Fabricius, 1787, Mant.Ins. 2:45 (*Papilio*)

Lethe rohria rohria(Fabricius)

Male genitalia

(Figs 27–31) Uncus long, sharply curved ventrally, base broad, setae small and sparsely arranged; brachia horn-like, very slender, upwardly lifted with pointed distal end; tegumen shorter than uncus, grooved mid-dorsally, hump-like, narrow ventrally; appendices angulares spine-like, slightly curved inwardly; vinculum with narrow strip except at distal end, longer than tegumen; saccus moderately long, almost uniform in breadth with rounded distal end; valva with proximal half broader and distal half narrow, pilose, costa and sacculus not properly demarcated, dorso-distal half inwardly curved; juxta V-shaped; aedeagus long, tubular, distal end broader and proximal end narrower and conical, squeezed near distal end, ductus ejaculatorius entering dorsad.

Female genitalia

(Fig. 32) Corpus bursae ellipsoidal, membranous; signa long, represented by scobinate patches, situated longitudinally, lying on one side of corpus bursae, extending from the caudal end to nearly middle of corpus bursae, strongly sclerotized; ductus bursae smaller than corpus bursae, broader anteriorly, narrower posteriorly, strongly sclerotized; lamella antevaginalis with globular, small central process, lateral lobes triangle-like with a minute spine on inner margin; lamella postvaginalis membranous; apophyses anterioris wanting; apophyses posterioris short, membranous, hook-like; papilla analis elongated, pilose.

Length of forewing, Male: 26.0–30.0 mm; Female: 28.0–32.0 mm

Material examined

Himachal Pradesh: 1♂, 16.ix.91, Kandaghat, 1440m, Solan; 1♂, 9.viii.94, Nauni, 1380m, Solan; 1♂, 1♀, 11.ix.92, Duttnagar, 1180m, Rampur, Shimla; 2♀♀, 10.ix.92, 1♂, 12.ix.92, Nogali, 1190m, Rampur, Shimla; 1♂, 7.ix.92, Rampur, 924m, Shimla; 1♀, 15.ix.92, Bhabhanagar, 1624m, Kinnaur; 1♀, 20.vi.93, Shamshi, 1220m, Kullu; 1♀, 8.vi.91, Manikaran, 1737m, Kullu; 1♂, 26.vi.92, Rivalsar, 850m, Mandi; 1♂, 22.iv.96, Banikhet, 1700m, Dalhousie, Chamba; 2♂♂, 19.iv.93, Tissa Bridge, 1750m, Tissa, Chamba; 1♀, 26.iv.92, Mcleodganj, 1768m, Dharmsala, 1387m, Kangra; 1♀, 11.v.93, Renuka, 660m, Sirmaur.

Uttar Pradesh: 2♂♂, 2.vi.93, 2♂♂, 3.vi.93, Bhilaru Pumping Station, 1710m, Mussoorie, Dehradun; 1♀, 12.vi.94, Mossyfalls, 1630m, Mussoorie, Dehradun; 1♀, 15.vi.94, Chakrata, 2135m, Dehradun; 1♀, 29.iv.92, 1♀, 29.vi.94, Tiffon Top, 1930m, Nainital, 1♀, 10.vi.92, Gopeshwar, 1219m, Chamoli.

Remarks

The collection of present species from the above mentioned localities shows that it has quite a wide range in the North-West Himalaya. This is contrary to D'Abrera (1985), who has mentioned that it is restricted in North India only.

Lethe europa (Fabricius)
Common name: The Bamboo Treebrown

Fabricius, 1775, Syst. Ent.:500(*Papilio*)

The male and female genitalia, and distribution record of this species has recently been published by Rose and Sharma (1999) and hence not given.

ACKNOWLEDGEMENT

Dr. H. S. Rose is grateful to the Indian Council of Agricultural Research, New Delhi (GOI) for funding the project on Butterflies.

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ABBREVIATIONS USED

AED – Aedeagus, APX.ANG – Appendix angulares, BR – Brachium, CO – Costa, CRP.BU – Corpus bursae, DU.BU – Ductus bursae, DU.EJ – Ductus ejaculatorious, DU.SEM – Ductus seminalis, LA.AV – Lamella antevaginalis, O.B – Ostium bursae, P.A – Papilla analis, PO.APO – Apophysis posterioris, SA – Saccus, SBZ – Subzonal portion of aedeagus, SIG – Signum, SL – Sacculus, SPZ – Suprazonal portion of aedeagus, TEG – Tegumen, UN – Uncus, VIN – Vinculum, VLV – Valva.

(Received in September 1999; revised and accepted in May 2000)

ENTOMON 25(2): 141–145 (2000)
Article No. ent.25209

A New Species of the Genus *Foersterella* Dalla Torre (Hymenoptera : Chalcidoidea : Tetracampidae) from India

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ABSTRACT: A new species *anupama* under genus *Foersterella* has been described and illustrated. This species is closely allied to *Foersterella scaposa* Boucek in having five segmented funicle and in the general appearance. However the new species can be easily distinguished on the basis of its different proportions of antennal segments, lengths of fore wing veins and colour of gaster and antenna.

KEYWORDS: Tetracampidae, *Foersterella*, new species.

INTRODUCTION

The beetles of the subfamily Cassidinae (Family : Chrysomelidae) include several major pests of agricultural importance. Members of the genus *Foersterella* Dalla Torre are known to be parasitic on the eggs of these beetles (Boucek, 1988). The genus *Foersterella* was errected by Dalla Torre in 1897 as replacement name for the genus *Hyperbius* Forster (Förster, 1878) which is preoccupied by *Hyperbius* Stal (Boucek, 1988). The genus is found to occur in Europe, Africa, India, New Guinea and Australia (Boucek, 1988). Very little work has been done on the taxonomy of Tetracampidae of India. Mani (1971) , Mani (1989) reported *Tetracampe indica* Mani from Uttar Pradesh and Subba Rao (1986) transfered this species to the genus *Epiclerus* Haliday. The present new species does not fit to the descriptions of any of the known species so far described (Boucek, 1958, 1988; Boucek and Askew, 1968; Mani, 1971, 1989; Burwell, 1998). This new species is described here and its affinities with its closest relative are discussed.

MATERIALS AND METHODS

The specimens of *Foersterella* were collected from the fields using specially designed hand nets and curated by the methods described by Noyes (1982). The specimens were mounted on rectangular cards and pinned with Asta insect pins of size 38 mm × 53

of No. 3 (made by Newy Goodman Ltd. U.K.). The observations were made using M3Z Wild Stereozoom (Switzerland) and Leitz-Watzlar (Germany) microscopes. The figures were drawn using drawing tube of Wild M3Z stereozoom microscope and enlarged using KB enlarger of model B2M.

Abbreviations

F = Funicular segment; OOL = Ocellocular distance; POL = postocellar distance; MV = marginal vein; PMV = post marginal vein; SMV = submarginal vein; STV = stigmal vein; T = tergite.

RESULTS

Description

Foersterella anupama *sp. nov. (Figs 1–4)*

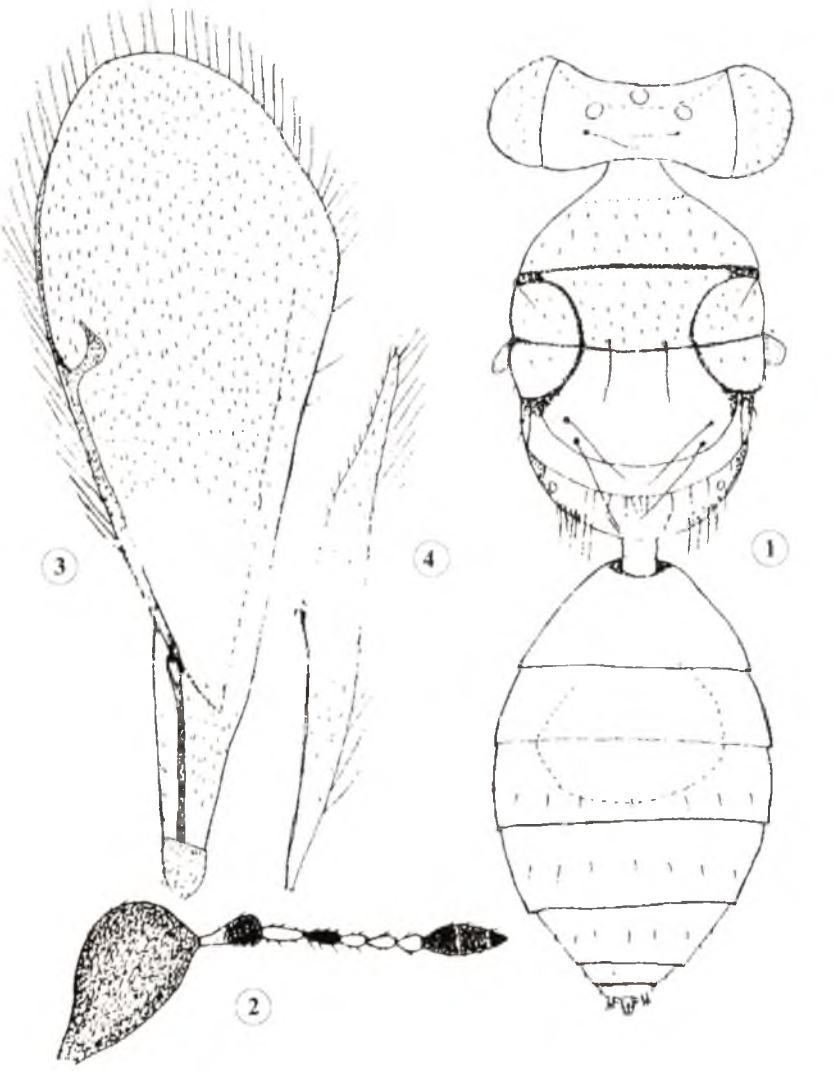
Holotype Male: Length 1.13 mm. Body metallic green, shiny; antenna black with basal half of pedicel, F1, F3, F4 and F5 whitish yellow (Fig. 2). Legs pale brownish yellow with hind coxa and fifth tarsal segment darker. Petiole pale brownish yellow; gaster dark metallic green with a large pale brownish yellow patch on T2 and T3 (Fig. 1). Wings hyaline, veins pale brown.

Head

Width in anterior view a little more than distance between front ocellus and lower clypeal margin (7 : 8); dorsal width of head 2.68x maximum of eye in dorsal view; vertex with spares hairs longer than breadth of clava; eye pubescent. POL 1.75x OOL; occipital carina present; funicle five segmented; scape 1.3x as long as maximum diameter of eye, both mesal and outer surface with conspicuous engraved reticulation-striation; pedicel distinctly shorter than combined length of F1 and F2; flagellum and clava as in Fig. 2. Relative measurements of length: width of antennal segments as follows: scape = 35 : 20.5; pedicel = 5.5 : 2; F1 = 8 : 3; F2 = 7.5 : 2.1; F3 = 5.5 : 2; F4 = 5.5 : 2; F5 = 5 : 3; clava = 17 : 6. Clava distinctly shorter than breadth of scape. Antennal formula=11053.

Mesosoma

Width lesser than width of head in dorsal view; dorsum of mesosoma with very faint and partly obliterated microscopic reticulation; sparse hairs on mesoscutum placed on raised papillae with a pair of larger setae on posterior margin submedially (Fig. 1); scutellum distinctly broader than long (38 : 23), both pair of bristles behind middle; each pair of bristles distinctly shorter than distance between them; hind tibial spur as long as metatarsus which is shorter than third tarsal segment. Fore wing length 2.85x its maximum width. Relative measurements of length: costalcell = 42; MV = 54; PMV = 42; STV = 9; parastigma continued posteriorly into a faint basal vein. Hind wing as a in Fig. 4, with two hamuli. Propodeum smooth and shiny with moderately dense pubescence, without any median or submedian carinae.



FIGURES. 1–4. *Foersterella anupama* sp.nov. Male: 1. Head, mesosoma and metasoma in dorsal view; 2. Antenna; 3. Fore wing; 4. Hind wing.

Metasoma

length 1.24x length of mesosoma; petiole subrectangular (not subtriangular as in *F. scaposa* Boucek). Relative median lengths of tergites as follows: T1 = 18; T2 = 14; T3 = 16; T4 = 16; T5 = 11; T6 = 4.

Female

Unknown.

Holotype

Male; India, Kerala, Calicut University Campus. Coll. T.C. Narendran, 10.viii.1999. Paratype: 1 female of same data of holotype. All types in the Department of Zoology, University of Calicut (Narendran Collection).

Etymology

The species name is a Sanskrit word meaning 'incomparable'; femenine gender.

DISCUSSION

This new species resembles its closest relative *Foersterella scaposa* Boucek in having scape 1.3x as long as maximum diameter of eye, both mesal and outer surface of scape with conspicuous engraved reticulation; sparse hairs on mesoscutum placed on raised papillae and in having scutellum distinctly broader than long. However it differs from *Foersterella scaposa* Boucek in having:

1. scape breadth distinctly more than length of clava (in *scaposa* about as wide as length of clava);
2. pedicel distinctly shorter than combined length of F1 and F2 (in *scaposa* pedicel about as long as combined length of F1 and F2));
3. antenna with scape, distal half of pedicel, F2 and clava black and remaining segments and basal half of F1 whitish yellow (in *scaposa* antenna brown with scape and F1 paler);
4. PMV distinctly shorter than MV (in *scaposa* PMV equal in length of MV);
5. MV 4.6x as long as STV (in *scaposa* MV 4x as long as STV);
6. costal cell of fore wing distinctly shorter than MV (in *scaposa* costal cell longer than MV);
7. Fore wing 2.85x as long as its maximum width (in *scaposa* fore wing 2.5x as long as its maximum width);
8. head slightly wider than mesosoma in dorsal view (in *scaposa* head about as wide as maximum width of mesosoma);
9. gaster with a large pale brownish yellow patch spread medially on T2 and T3 (in *scaposa* no such patch present)
10. gaster a little longer than 1.6x its maximum dorsal width (in *scaposa* gaster shorter than 1.6x its maximum width and
11. petiole subrectangular (in *scaposa* petiole subtriangular).

ACKNOWLEDGEMENTS

Thanks are due to the authorities of University of Calicut for providing facilities for undertaking this work. Dr. Z. Boucek was kind enough to send a photocopy of his 1958 paper on Tetracampidae.

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(Received in September 1999; revised and accepted in May 1999)

ENTOMON 25(2): 147–150 (2000)
Short Communication No. ent.25210

A new record of *Apanteles agilis* Ashmead (Hymenoptera : Braconidae), from the leaf-roller pest of mulberry, *Diaphania pulverulentalis* (Hampson) from India

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ABSTRACT: *Apanteles agilis* Ashm. (Hymenoptera : Braconidae) is reported for the first time from the leaf-roller pest of mulberry *Diaphania (=Margaronia) pulverulentalis* (Hampson) (Lepidoptera : Pyralidae), a serious pest of mulberry, *Morus alba* L. (Moraceae). It is a solitary, larval, endo-parasitoid. This parasitoid occurs during winter. Details of occurrence of *A. agilis* in different areas and some aspects of morphology of its cocoons and adult parasitoids are presented.

KEYWORDS: *Apanteles agilis*, *Diaphania pulverulentalis*, *Morus alba*.

Apanteles agilis Ashm. (Hymenoptera : Braconidae) is recorded for the first time from the leaf-roller pest of mulberry, *Diaphania (=Margaronia) pulverulentalis* (Hampson) Lepidoptera : Pyralidae). This parasitoid has earlier been recorded from *Hidari irava* Moore (Lepidoptera : Hesperiidae), a pest of coconut, in Dutch East Indies (Wilkinson, 1928; Tjien, 1940). The type locality of the species is Manila, Philippines (Ashmead, 1905). Rohwer (1922) reported this species from *Hidari* sp. from Sumatra and Java.

D. pulverulentalis is a severe pest of mulberry, *Morus alba* L. (Moraceae) since 1995 in Karnataka (Geetha Bai *et al.*, 1997) and has also spread to the neighbouring Tamil Nadu and Andhra Pradesh states. During a survey conducted in Karnataka for three years since September 1995, the parasitoid complex of *D. pulverulentalis* was studied and *Phanerotoma noyesi* Zettel (Hymenoptera : Braconidae) was found to be the most common parasitoid (Geetha Bai *et al.*, 1997; Anonymous, 1998); its life-history has been reported (Marimadaiah and Geetha Bai, 1999).

A. agilis is a solitary, larval endo-parasitoid of *D. pulverulentalis*. This parasitoid occurs during winter, when the temperature is low (Table 1). It was first recorded during December 1996 at B. K. Doddi, Mandya district and parasitism recorded was 5.6%. Of the 36 samples collected during September 1995 to August 1998, at monthly intervals, at Yerehalli village in Bangalore district, *A. agilis* occurred during December

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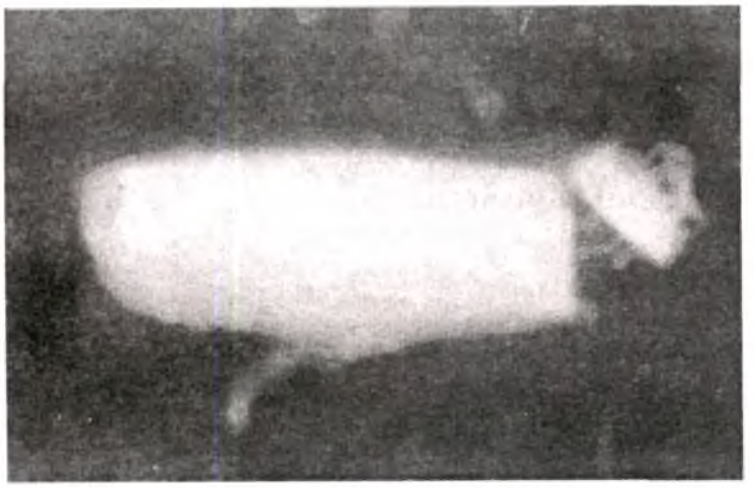

FIGURE 1. Cocoon of *Apanteles agilis*.

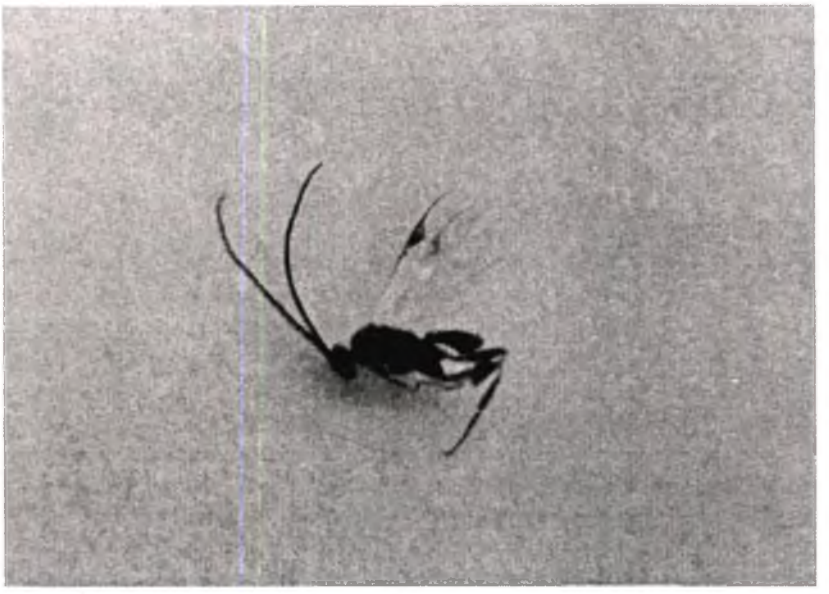

FIGURE 2. Adult male *Apanteles agilis*.

1997 and January 1998 and parasitism recorded was 11.1 and 10.5%, respectively. It was recorded at Bhujavalli village, Mandya district during January 1998, KSSRDI, Thalaghattapura and Kumbalgodu village in Bangalore district during February 1998

TABLE 1. Occurrence of *Apanteles agilis*, a parasitoid of *Diaphania pulverulentalis* in Karnataka

Period	Place of collection	No. of caterpillars observed	No. of caterpillars parasitised	Parasitism (%)
Dec. 1996	B.K. Doddi Mandya dist.	36	2	5.6
Dec. 1997	Yerehalli B'lore dist.	99	11	11.1
Jan. 1998	Yerehalli B'lore dist.	57	6	10.5
Jan. 1998	Bhujavalli Mandya dist.	100	1	1.00
Feb. 1998	KSSRDI Thalaghattapura B'lore dist.	83	1	1.2
Feb. 1998	Kumbalgodu B'lore dist.	61	1	1.64

and parasitism recorded was 1.0, 1.2 and 1.64%, respectively, suggesting that activity of this parasitoid was low in these areas.

Field collected leaf-roller caterpillars were isolated in glass vials and reared in the laboratory. Fully developed parasitoid larvae, after completion of their feeding stage, emerged from the host caterpillars. They secreted a white silky substance, which was used to fold the leaf, inside which they spun a cocoon, on the upper surface of mulberry leaf and pupated inside. Cocoons were white in colour, elongated, cylindrical with blunt ends.They measured 2.15–3.92 mm (Av. = 3.36 ± 0.53 mm) in length and 1.17–1.62 mm (Av. = 1.40 ± 0.15 mm) in breadth. Adult parasitoids emerged, after cutting a circular lid at one end of the cocoon (Fig. 1). Body colour of adult parasitoids was black and the legs were brown. The two pairs of wings were thin, papery and transluscent. Female parasitoids were larger than males and possessed a prominent ovipositor (Fig. 2). Female *A. agilis* measured 2.34–2.46 mm (Av. = 2.38 ± 0.06 mm) in length and 0.71–0.77 mm (Av. = 0.74 ± 0.03 mm) in breadth. Male parasitoids measured 2.00–2.23 mm (Av. = 2.09 ± 0.11 mm) in length and 0.62–0.70 mm (Av. = 0.69 + 0.06 mm) in breadth. Possibilities of using this parasitoid for biological control of the leaf-roller pest during winter is being explored.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. S. B. Dandin, Director, and Dr. R. Raghuraman, Divisional Chief, KSSRDI for the facilities and the supporting staff of Entomology

Unit, for assistance. Thanks are due to Prof. T. C. Narendran, University of Calicut, for identifying the parasitoid.

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(Received in June 1999; revised and accepted in April 2000)

ENTOMON 25(2): 151–154 (2000)
Short Communication No. ent.25211

Effect of Higher Temperatures on *Ascogregarina culicis* (Protozoa, Apicomplexa), the Gregarine Parasite of the Mosquito *Aedes aegypti*

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ABSTRACT: Oocysts of *Ascogregarina culicis*, the gregarine parasite of *Aedes aegypti* was found to be tolerant to 50 °C for about 5min. The infectivity of oocysts was almost 100% when maintained on filter papers at room temperature for 90 days. However, when *Ae. aegypti* larvae infected with trophozoite stage of the parasite were exposed to varying higher temperatures for 60 min, it was found that exposure of the late second instar to 41 °C not only minimised the host mortality due to heat shock but also eliminated the parasite infection. This technique could be employed to obtain gregarine parasite-free colonies needed for carrying out susceptibility studies of insecticides and viruses on the mosquitoes.

KEYWORDS: *Ascogregarina culicis*, *Aedes aegypti*, Heat-shock, Host-parasite interaction.

Protozoan parasites of mosquitos are known to interfere with the vector competence of the host to virus (Akhtar *et al.*, 1981) and shown to have a combined effect on their susceptibility to insecticides (Mourya and Soman, 1987). Therefore a clean mosquito colony is essential to study their susceptibility to viruses and insecticides. We have earlier reported that despite hygienic precautions the gregarine parasite could not be eliminated from the mosquito colony (Mourya and Dhanda, 1981). Attempts to use antiamoebic drugs to eliminate the parasite from the larval stages also were not successful (Mourya *et al.*, 1985). Recently, while carrying out experiments to determine the effect of higher temperatures. It was observed that the parasites could not withstand exposure to high temperature while the host could. The emerging adults were found to be free of parasites. The present communication reports these observations.

A colony of *Ae. aegypti* mosquitoes 100% infected with *Ascogregarine culicis* was developed as described earlier (Mourya and Dhanda, 1981). A series of glass jars, each containing the hundred, I-instar larvae in 100 ml distilled water were treated with a dose of 500 oocysts/ml, which is shown to produce 100% infectivity in the

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TABLE 1. Infectivity of *Ascogregarina culicis* for *Aedes aegypti* after heat shock for 60 min

Shock Temperature	Larval instar		
	II	III	IV
37 °C	(80/80) 100*	(80/80) 100	(80/80) 100
39 °C	(58/80) 72.5	(70/80) 87.5	(78/80) 97.5
41 °C	(0/80) 0.0	(0/80) 0.0	(0/80) 0.0

*(Number of adults positive/number examined) Present positive.

TABLE 2. Percent IV instar larvae positive for *Ascogregarina culicis* when exposed at I instar to the oocysts suspensions which were heated at various temperatures

Oocysts suspensions heated at temperatures (°C)						
30	35	40	45	50	55	60
100*	100	100	100	99	3	0

*Percent IV instar larvae positive for trophozoites. Two replicates were done in each experiment the heat shock was given for 5 min.

mosquitoes with a very high parasite load (Mourya *et al.*, 1985). Different larval instars were exposed to temperatures ranging from 37 to 43 °C for 60 min. There were heavy mortality when the temperature of the circulating water bath was above 41 °C. When the parasite-infected late II-instar larvae were exposed to 41 °C for 60 min and dissected later when they entered IV-instar stage, they showed almost no gamonts. However, when the infected IV-instar larvae were exposed to the same temperature gamonts were seen in the gut, the gamonts were non-motile and damaged in the gut as compared to the unexposed controls. These gamonts could not complete their development up to gametocyst formation and so the emerging mosquitoes were free of the parasites (Table 1). When the emerging adults were maintained separately, away from the normal colony and observing hygienic precautions, *A. culicis* infection was not detected in the mosquitoes in the following generation. Developmental stages of the parasite were found to be vulnerable to exposure of the host to higher temperature. Further experiments were carried out to see the effect of higher temperatures on the oocysts, which are found in the malphighian tubes of the infected adults. Since the adult mosquitoes cannot withstand such higher temperature, the oocysts were harvested from the infected mosquitoes and the oocysts suspensions were exposed to varying temperatures. Freshly emerged I-instar larvae were allowed to feed on these heated oocyst suspensions. These larvae were examined for the presence of the parasite as mentioned above.

Results obtained from two replicates of the experiments showed that oocysts were comparatively more resistant to higher temperatures than the developing stage

TABLE 3. Percent IV instar larvae positive for *Ascogregarine culicis* when exposed at I instar to the oocysts suspensions which were preserved on filter papers at room temperature for various periods of time

Oocysts at room temperature (25 ± 7 °C)				
	Days			
Conditions	7	15	30	90
Dry	100*	100	100	96
Humid	100	100	100	100

*Percent IV instar larvae positive for trophozoites.

(Table 2). Similarly, oocysts suspensions were blotted on filter papers and maintained in dry and humid conditions for several days. Their infectivity was examined by exposing them to freshly emerged I-instar larvae as mentioned above. It was found that the infectivity of oocysts was almost 100% at room temperature for 90 days (Table 3). This indicates the ability of the parasite to survive in nature during the non-mosquitogenic seasons. It is known that heat shock of 41 °C produces heat shock proteins in this species (Lan and Fallon, 1990). There are other reports where a correlation of heat shock and virus multiplication has been shown in *in vitro* (Carvalho *et al.*, 1987; Tatem and Stollar, 1989). We feel that by giving heat shock to the mosquitoes at the larval stages a parasite-free colony can be developed, if not in the same generation at least in the next generation. This clean colony can be used to carry out studies on the susceptibility of these mosquitoes to insecticides and viruses.

ACKNOWLEDGEMENTS

The technical help rendered by Mr. K. A. Pillay during this study is gratefully acknowledged. The authors DTM & VSP are also thankful to the Department of Biotechnology, Government of India, for their financial support.

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(Received in October 1999; revised and accepted in May 2000)

ENTOMON **25(2):** 155–158 (2000)
Short Communication No. ent.25212

Occurrence of a New Whitefly Species of the Neotropical Genus *Crenidorsum* Russell (Homoptera : Aleyrodidae)

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ABSTRACT: In a survey and taxonomic study of South Indian whiteflies (Homoptera : Aleyrodidae), the Neotropical genus *Crenidorsum* Russell was found to occur on plants of *Randia* spp. (Rubiaceae). The new species is described as *Crenidorsum russellae* with illustration.

KEYWORDS: whitefly, new species, *Crenidorsum russellae* with illustration.

INTRODUCTION

Whiteflies are an economically important group of insects infesting a wide range of host plants (Mound and Halsey, 1978). Species like *Bemisia tabaci* (Gennadius) are cosmopolitan in distribution. However, many species have restricted geographical distribution with a chance of spreading into new geographic areas, attacking previously uninfested plant species (Russell, 1990). The recent introduction into India of the spiralling whitefly, *Aleurodicus dispersus* Russell (Russell, 1965), is a typical example of this kind (David and Regu, 1995). An extensive survey and taxonomic study of the South Indian whiteflies conducted during 1991–95 revealed the occurrence of a new species belonging to the Neotropical genus *Crenidorusm* Russell (Russell, 1945) which is described here.

***Crenidorsum russellae* sp. Nov. (Fig. 1)**

Pupal case

Colourless and membranous without any waxy secretion, scattered on the lower surface of leaves. Broadly oval, ends broadly curved; 0.84–0.87 mm long and 0.65–0.72 mm wide, widest across abdominal segments I and II.

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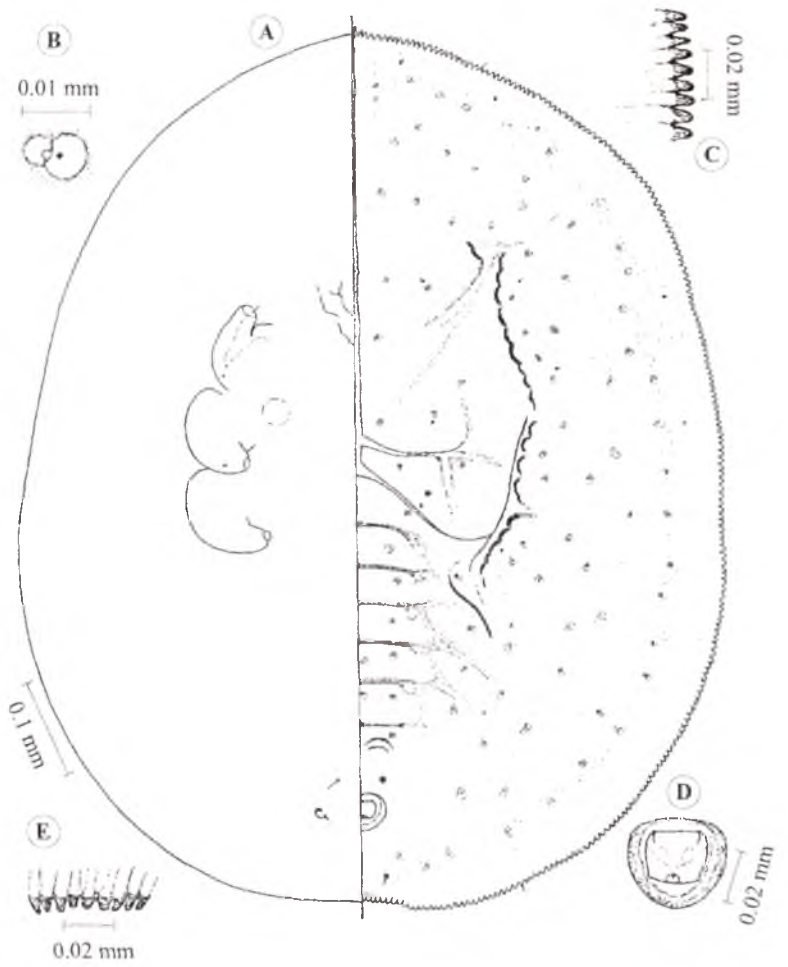

FIGURE 1. *Crenidorsum russellae* sp. nov.: **A** pupal case; **B** disk pores and porettes; **C** section of margin and submargin; **D** vasiform orifice; **E** caudal tracheal pore area.

Margin

Strongly dentate, 15 teeth in 0.1 mm width of margin, their apices broadly conical to rounded, slightly longer than wide; 2 or 3 teeth at each tracheal pore area somewhat different from other teeth. Anterior and posterior marginal setae 15.5 μg long.

Dorsum

Sumarginal lines running mesad into subdorsum. Inner subdorsal longitudinal row of scallop-shaped thickenings numbering 18–24 in three groups extending from posterior cephalus to abdominal segment III. A ridge mesad of median and posterior groups of

thickenings. A distinct ridge mesocaudad of anterior group of thickenings on cephalic segment with 1–2 scallop-shaped thickenings anteriorly at right angle to the ridge. A prominent submedian ridge posterior to the posterior group of thickenings extending mesolaterad of abdominal segments III and IV. Another submedian ridge extending from mesothorax and metathorax without any scallop-shaped thickenings. Bases of dorsal setae porous-appearing. Cephalic setae minute, 6.2 μ. Two submedian pairs of minute setae, one pair each on mesothorax and metathorax, 3.1 μ long. Submedian pair of first abdominal setae absent. Eighth abdominal setae 6.2–27.9 μ long, located anteriad of vasiform orifice. Caudal setae 12.4–40.3 μ long, located on inner submargin. Subdorsal setae minute, in 5 pairs: 2 pairs on cephalothorax laterad of anterior group of scallop-shaped thickenings; 3 pairs on abdomen, 1 pair laterad of posterior group of scallop-shaped thickenings on abdominal segment II, 1 pair each laterad of abdominal segment IV and VI. Submarginal setae in 5 pairs on cephalothorax, very minute, 3.5 μ long. Longitudinal moulting suture reaching margin. Transverse moulting suture curved caudad from its midpoint, recurved terminating at or laterad of subdorsal ridge. Meso-metathoracic suture distinct; ends of mesothoracic suture curved cephalad, that of metathoracic suture curved caudad. Abdominal segmentation and sutures well defined in submedian area. Abdominal rhachis discernible. Median length of cephalic segment longer than that of thoracic segments; median length of abdominal segments subequal; median length of abdominal segment VII shorter than that of VI. Submedian depression rather weak; abdominal sutures ending in a dark sclerotized spot mesad of each depression. Seventh abdominal pockets distinct, not contiguous. Disc pores and porettes present as illustrated. Disc pores and porettes characteristically in pairs, one larger and the other smaller; porettes each inside larger pores entirely sclerotized, porettes each inside smaller pores with only dark rims. Vasiform orifice subcordate, located about its length from posterior suture and greater than its length from posterior body margin; 65.1 μ long and 37.2 μ wide, its top rather straight, inner sides and caudal margin with minute ridges. Operculum subrectangular, filling the orifice, 21.7 μ long and 24.8 μ wide. Lingula obscured, its apex slightly exposed. Caudal furrow and caudal ridges not discernible.

Venter

Ventral abdominal setae 15.5 μ long. Thoracic and caudal tracheal folds very faint. Spiracles evident. Antennae reaching to anterior spiracles. Seta at base of legs not discernible. Adhesive sacs present.

Host *Randia malabarica* (Rubiaceae)

Holotype A pupal case mounted on slide, on *Randia malabarica*. INDIA: Tamil Nadu, Madurai, 26.i.94. Coll: P.M.M. David (No. 250.1).

Paratypes 23 pupal cases, on *R. malabarica*, Madurai, 26.i.1994. P.M.M. David; 17 pupal cases on *Randia brandisi*, Madurai, 26.i.1994, P.M.M. David.

Diagnosis This species is related to the Neotropical species *Crenidorsum leve* (Russell, 1945) in possessing colourless, membranous derm without any waxy secretion, in the structure and number of marginal teeth, in the ridge that follows the row of small scallops terminating on abdominal segment IV, and in the absence of median tubercles. It differs from *C. leve* in the presence of minute submarginal setae in 5 pairs on cephalothorax, of fewer scallop-shaped thickenings in each row (18–24 as against 40–55 in *C. leve*) and subdorsal setae (5 pairs as against 3 pairs on cephalic segment in *C. leve*) and of mesothoracic setae. The structure of vasiform orifice is subcordate as against semioval in *C. leve*.

Etymology Named after the renowned whitefly specialist Dr. Louise M. Russell of the Systematic Entomology Laboratory, Entomology Research Division, United States Department of Agriculture, Washington D.C. as a token of respect and esteem.

Types Depository The holotype is deposited with the Division of Entomology, Indian Agricultural Research Institute, Pusa campus, New Delhi. The paratypes are available with the Centre for Advanced Studies in Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore; with Dr. B. V. David, Director, Jai Research Foundation, Vapi; and with the Department of Entomology, Natural History Museum, London.

ACKNOWLEDGEMENT

The authors are grateful to Dr. Abraham Muthukumar of St. John's College, Palayamkottai for identifying the host plants.

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(Received in August 1999; revised and accepted in March 2000)

ENTOMON 25(2): 159–160 (2000)
Short Communication No. ent.25213

Incidence of Tick Infestation in Asiatic Cross Bred Lions

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ABSTRACT: Incidence of infestation with *Rhipicephalus sanguineus* ticks in captive Asiatic cross bred lions has been documented and the probable infections related with these tick infestations are also discussed.

KEYWORDS: *Rhipicephalus* species—ticks—Asiatic Cross bred lions.

Documentation on tick infestations in domesticated animals is adequately available. However, information on tick infestations in captive lions is limited. The tick infestation in wild felids has been emphasized by Fowler (1986). The species like *Dermacentor* sp., *Haemaphysalis* sp. are the acarines encountered in wild felids (Wallach and Boever, 1983). Though tick infestation is not a common feature in cats, infestation with *Ixodes* sp. has been reported to occur (Chandler *et al.*, 1994). Lancaster and Meisch (1986) reported that felids may get affected by Hepatozoonosis and Levine (1985) reported on the incidence of Babesiosis both in domestic and wild felids in India and the ticks get involved in the transmission of these diseases. Similarly, August (1994) opined that Ixodid ticks also transmit the Ehrlichia organisms and Sherding (1994) quoted on the experimental infection of cats with *Ehrlichia risticii*, *E. equi* and *E. canis*.

During a routine investigation on the health status of the captive Asiatic cross bred lions reared in Arignar Anna Zoological Park, Vandalur, mild tick infestation was observed in the sides of the neck region during September, 1999. The ticks were duly collected, preserved in 70 per cent alcohol for further detailed examination.

These ticks were identified as *Rhipicephalus sanguineus* based on the keys furnished by Soulsby (1982). The significant features observed in this parasite were hexagonal basis capitulum and festoons.

During observation of the macroscopic structures, the parasites under this study were found to have prominent ventral plates by which, the ticks were identified easily from the study animal.

The vector potentiality of the *Rhipicephalus sanguineus* in the transmission of Babesiosis, Hepatozoonosis and Ehrlichiosis has already been proved in domesticated

canids and felids. Hence, the presence of such tick infestation in captive wild felids may pose a threat and thus may warrant the ruling out of the haemoprotozoan infections. However, in the study animals, no such incidence of haemoprotozoan diseases was recorded during the investigation.

Though Ivermectin is not recommended for use in cats in both USA (Sherding, 1994) and UK (Chandler *et al.*, 1994), this drug still finds its usage as an effective endecticide. Sherding (1994) quoted on the dose rate of Ivermectin as 200–400 μg per Kg body weight, by S/C route and needs to be repeated 2–3 times at 14 days interval. In the zoo atmosphere, whenever the conditions warrant the use of anti tick measures, it should be remembered that all incontact wild felids should be treated because inapparent carriers may act as a source of reinfestation.

The occurrence of Brown dog tick namely *Rhipicephalus sanguineus* in Asiatic cross bred lions maintained under captive conditions is reported in this paper.

ACKNOWLEDGEMENT

The technical helps and facilities rendered by Professor and Head, Department of Parasitology and Director, Arignar Anna Zoological Park, Vandalur and Dean, Faculty of Basic Sciences, Madras Veterinary College are greatly acknowledged.

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(Received in October 1999; revised and accepted in May 2000)

AUTHOR INDEX

Reg. No. 123SBN

Edited, printed and published by Prof. D. Muraleedharan for and on behalf of Association for Advancement of Entomology, Department of Zoology, University of Kerala, Trivandrum. Typeset in TEX by River Valley Technologies, Trivandrum. Printed at St. Joseph's Press, Trivandrum.